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# USSR Report

## MATERIALS SCIENCE AND METALLURGY



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## MATERIALS SCIENCE AND METALLURGY

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ALUMINUM AND ITS ALLOYS

UDC 669.715:620.1

# DYNAMIC RECRYSTALLIZATION OF ALUMINUM ALLOYS

Moscow TSVETNYYE METALLY in Russian No 2, Feb 84 pp 67-70

VAYNBLAT, Yu. M. and SHARSHAGIN, N. A.

[Abstract] Primary recrystallization may follow or be simultaneous with deformation, in a dynamic form powered by reserve deformation energy at high temperature. In the process recrystallization growth energy constantly decreases as a result of deformation tempering, and reserve energy, diffusion mobility and recrystallization time are not independent. The present article describes a new model for dynamic recrystallization of aluminum that makes it possible to determine all conditions involved in the process. The tested aluminum and alloys had not previously manifested dynamic recrystallization with new granule formation. Temperature and compression factors causing granules to be flattened are discussed. The notched granular structure observed is attributed to local migrations that are a variation of dynamic recrystallization. After deformation was halted, the dynamic motivating force disappeared, leaving only the difference in reserve energy to cause crystal changes. Three types of dynamic recrystallization are identified: simple extrusion from slightly alloyed metals under high stretching levels, local zones of intense shifting deformation, and microscopic irregularities of plastic deformation. Figures 4; references 13: 10 Russian, 3 Western. [81-12131]

UDC 669.715-416:620.1

EFFECT OF COLD-ROLLING TEXTURE ON FORMATION OF CUBIC ORIENTATION IN ANNEALING ALUMINUM CONDENSOR FOIL

Moscow TSVETNYYE METALLY in Russian No 2, Feb 84 pp 76-77

GRIGOR'YEV, A. K., SIL'NIKOVA, Ye. F. and PEVZNER, M. Z.

[Abstract] Recent studies have shown that increasing the cubic orientation in annealed condensor foil results in high mean volume, making it possible to reduce the size of aluminum electrolytic condensors. The authors studied the relationship between rolling texture type and cubic textural orientation in A99 aluminum foil of 100 micron thickness. After homogenization at 570-590°C, the foil was annealed at 530°C for 5 hours, then subjected to $FeK_{alpha}$ irradiation to determine its structure. The minimum value for cubic orientation in the texture of cold-rolled foil assured maximum intensity of cubic orientation in foil rolled from ingots either with or without homogenizing annealing. References 4: 3 Russian, 1 Western.
[81-12131]

UDC 669.715:620.1

EFFECT OF TEXTURE ON CAPACITY OF ALUMINUM ALLOYS FOR DEEP STRETCHING

Moscow TSVETNYYE METALLY in Russian No 2, Feb 84 pp 74-76

KURTASOV, S. F.

[Abstract] The structure of single-phase aluminum alloys determines anisotropy of plastic properties. The present article reports on the formation of scallops during deep stretching in making cylindrical objects from flat ingots. A macroscopic theory of plastic anisotropy was supplemented by additional parameters of such metal objects, such as crystal orientation, tangential compression tension, crystal shift and creep tension. Experimental data on cylindrical aluminum articles were processed to establish a statistical profile, although numerous factors were not considered. Three-dimensional textural functions, monocrystal orientation and the texture of the polycrystalline article were taken into account, but wall thickness at the base of the cylinder, unstationary factors during stretching and irregularities of the cylinder were not. Nevertheless, the mathematical model was considered to be an accurate description of basic features of the stretching process. Figures 1; references 5: 4 Russian, 1 Western.
[81-12131]

UDC: 669.715:539.6

FRACTURE TOUGHNESS OF ALUMINUM CASTING ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 19, No 6, Nov-Dec 83 (manuscript received 30 Mar 83) pp 53-56

POLISHCHUK, V. M., Kiev Institute of Civil Aviation Engineering

[Abstract] Results are presented from experimental studies to determine the critical fracture toughness coefficient of the aluminum casting alloys VAL10, AL9 and the forging alloy AK6 for comparison purposes. The tests were performed on specimens 75 mm thick (VAL10 and AL9) and 50 mm thick (AK6) manufactured from special cast blanks measuring 200 x 200 x 85 mm (forged blank 230 x 230 mm for AK6). Mechanical properties of the castings were tested on separate specimens as well as specimens cut from the casting. Macrosections were used to determine the approximate porosity of the specimens in the area where the fatigue cracks developed and propagated. The results showed the alloy VAL10 to have a favorable combination of high strength and fracture toughness. Figures 3; references 5: 3 Russian, 2 Western.
[54-6508]

UDC; 539.43:620.178.3

INFLUENCE OF COMPOSITION ON FATIGUE RESISTANCE AND CRACKING RESISTANCE OF PRESSED SEMIFINISHED GOODS OF Al-Cu-Mg and Al-Zn-Mg-Cu ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 10 May 82) pp 124-128

VOVNYANKO, A. G. and DRITS, A..M., Moscow

[Abstract] A study is made of the influence of iron and silicon, as well as the content of copper and zirconium in D16ch and zirconium in V95tch alloys on fatigue resistance and crack resistance of pressed semifinished goods. Fatigue durability studies were performed on specimens with apertures and lugs with theoretical stress concentration coefficient 2.6 and 3.2, at frequencies of 2 and 40 Hz. Fatigue curves were constructed in coordinates of maximum cycle stress versus number of cycles in logarithmic scale. Studies were performed on pressed strips measuring 7 x 100 x 4000 mm as well as large pressed panels. Highly pure specimens containing very little iron and silicon were also studied. The studies showed that further increases in purity have little influence on static strength but increase ductility and impact toughness. Replacing manganese and chromium with zirconium in V95tch also increases ductility and impact toughness. Decreasing copper and manganese and increasing zirconium in D16ch improves fatigue durability by a factor of 2-2.5 and decreases crack growth rate. Figures 4; references 9: 6 Russian, 3 Western.
[65-6508]

UDC: 669.715:539.56

# TOUGHNESS OF FRACTURE OF CAST ALLOYS IN THE SYSTEM Al-Mg-Zn-Cu

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 9 Mar 82) pp 120-123

BELOV, N. A., YESEYEV, Yu. V. and ZOLOTOREVSKIY, V. S., Moscow

[Abstract] A study is made of the variation of fracture toughness ($K_{1c}$) as a function of composition of cast and heat treated high strength Al-Mg-Zn-Cu alloys in order to establish the relationship of this characteristic to microstructural parameters. Alloys for the study were prepared in a resistance furnace in a graphite-chamotte crucible after the melt was refined with hexachloroethane. Hardening was found to improve the mechanical properties of all alloys by complete or partial dissolution of excess phases. Aging decreases fracture toughness in most alloys, particularly with an increase in content of zinc, though in alloys containing up to 8% Mg and 3% Zn aging slightly increases $K_{1c}$ while simultaneously hardening the specimens. Mathematical models of the variation of fracture toughness, strength properties and microstructural parameters as functions of composition in the cast, hardened and aged states are constructed. The optimal combination of the chemical properties is observed in aluminum alloys with 5-8% Mg and 3% Zn. Figures 4; references 8: 7 Russian, 1 Western.
[65-6508]

UDC 669-494

## FIBER STRESS AND INTEGRITY IN COMPACTION OF FIBROUS COMPOSITES WITH POROUS METALLIC MATRIX

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84
(manuscript received 8 Jul 82) pp 121-127

AREF'YEV, B. A., Moscow

[Abstract] A mathematical analysis was made of the forces and stresses to which fibers are subjected in composites with porous metal matrix, using the "elementary cell" model of Tuchinskiy for studying and approximating deformation in composites. Evaluation of normal and tangential stresses on the fibers demonstrated that as deformation due to compaction increases and the porosity of the matrix decreases, the contact stresses on fibers at the fiber-matric interface increase. Deformation of the matrix occurs largely in a manner transverse to the fibers in the composite. The plastic flow of the matrix along the fibers subjects the fibers to stretch forces and may lead to fiber breakdown if the force exceeds the stretch resistance of the fiber. Breakdown of the fibers was calculated to occur only when the porosity of the matrix approaches zero value, and depends on the chemical composition and plasticity of the matrix. Figures 5; references 5: all Russian. [82-12172]

UDC 539.3/6:539.216.1

## PREDICTING ELASTIC PROPERTIES OF UNIDIRECTIONAL FIBROUS COMPOSITE MATERIALS WITH INDEPENDENT STRESS STATES

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 84
(manuscript received 12 Aug 82) pp 45-49

KUZ'MENKO, B. P. and SADAKOV, O. S., Chelyabinsk Polytechnic Institute

[Abstract] Previous studies of unidirectional fibrous composite materials have not presented complete models, or else have used complex mathematical calculations that cannot be applied in practical engineering. The authors suggest a simplified model in which the stress state is reflected by certain

average tensors, and the determining coefficients are reduced to fiber volume and the relationship between the elasticity module of the matrix and the fibers. Calculations to prove the validity of the approach result in 6 coefficients instead of the former 81. The calculations were tested in experiments with S-glass and an epoxy matrix, and with boron and metallic fibers. The tensor form of calculating mixtures was found to be sufficiently flexible and accurate. Figures 3; references 10: 9 Russian, 1 Western. [71-12131]

ENERGY EFFECTS

UDC 535.211:536.21

## OPTIMIZATION OF STEEL TEMPERING PARAMETERS BY $CO_2$ LASER BEAM

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 23 Jul 81) pp 94-98

MORYASHCHEV, S. F., KISLITSYN, A. A. and KOSYREV, F. K., Moscow

[Abstract] Mathematical analysis was performed on the tempering of several steel samples with a $CO_2$ laser ($\leq$5 kW), by evaluating the depth of tempering in relation to surface temperature and absorption vis-a-vis laser beam movement. Empirically derived data are summarized for the low-alloy steels 40Kh, 65G, St45, 4Kh13 and Armco. The data were used to derive equations describing determination of the surface are $\alpha$ and volume tempered in a given unit of time, and can be used for designing laser applications for maximum reproducibility in tempering. Figures 3; references 6: all Russian. [82-12172]

UDC 669.2/9

## EFFECTS OF ELECTRIC CURRENT ON PHASE COMPOSITION AND STRUCTURE OF GRANULATED HIGH-SILICON SILUMIN

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 25 Mar 82) pp 88-93

TARAN, Yu. N., PRIGUNOVA, A. G., MAZUR, V. I., BEREZA, Ye. Yu., SAVEL'YEV, V. S. and BULYCHEVA, V. N., Dnepropetrovsk

[Abstract] Studies were conducted on the effects of rapid quenching and application of alternating electric current to granulated high-silicon (35-40%) Silumin (Fe, Ti, Zr and Ca < 6%) melts at 1200-1300°C on the phase composition and structure of the solid alloy. Rapid quenching ($>10^3$ °K/sec)--as opposed to slow quenching at a rate of $10^{-1}$ °K/sec--resulted in metastable intermediate phases and supersaturated solid solutions. Pretreatment with alternating current led to the formation of a more homogenous melt as a result of an increase in the number of crystallization nuclei, reduction in

the size of the crystals, and increased supersaturation of the alpha-solid solution. Consequently, it is evident that the structure and properties of Silumin can be controlled by a combination of rapid quenching and alternating current treatment. Figures 4; references 12: 11 Russian, 1 Western. [82-12172]

UDC 546.824.21

PHASE COMPOSITION OF PRODUCTS FORMED IN ELECTRIC DETONATION OF CUBIC $TiC_xO_y$ AND $TiC_xO_yH_m$ PHASES

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 17 Jun 81) pp 47-50

PAVLOV, I. Ye., Nikolayev

[Abstract] A study was made of the lattice constants and phase composition of the products obtained by electric detonation of NaCl-type cubic $TiC_xO_y$ and $TiC_xO_yH_m$ phases in distilled water. The large and small fractions of the products differ in phase composition and lattice constants, indicating differences in crystallization. Detonation of a fine fraction sample of $TiC_xO_y$ resulted in a product containing the original phase, while detonation of a large fraction sample resulted in the formation of small quantities of graphite and $TiO_2$. Detonation of $TiC_xO_yH_m$ led to loss of hydrogen, as indicated by the decrease in the lattice constant; the latter was particularly remarkable in the case of the large fraction sample. On the whole, the test substances were found to be quite stable under the experimental conditions. References 15: all Russian.
[82-12172]

UDC 621.785.787.044

NITRIDING OF VT9 TITANIUM ALLOY AFTER SHOCK WAVE TREATMENT

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 30 Aug 82) pp 43-46

BEKRENEV, A. N. and KIRILENKO, Yu. N., Kuybyshev

[Abstract] The effectiveness of nitriding VT9 titanium alloy following shock wave treatment was investigated by exposing the alloy to a 2--12 GPa planar wave from an explosion, followed by saturation of the alloy surface with nitrogen under a pressure of $10^5$ Pa at temperatures ranging from 500 to 850°C. Subsequent analysis of the crystalline structure of the alloy demonstrated that shock wave treatment promotes nitroding at relatively low temperature compared withthe temperatures of 800-950°C required for undeformed alloys. The greater efficiency of nitriding of the deformed samples

was ascribed to tubular dislocations which enhance nitrogen atom transport into the deformed alloy, and result in nitrogen concentrations in the superficial layers of the alloy that are much greater than in the undeformed samples at all the annealing temperatures. Figures 4; references 8: all Russian.
[82-12172]

UDC 535.211:539.219.3

SURFACE ALLOYING OF METALS BY CONTINUOUS LASER EMISSION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 20 Mar 82) pp 19-23

BOROVSKIY, I. B., GORODSKIY, D. D., SHARAFEYEV, I. M. and MORYASHCHEV, S. F., Moscow

[Abstract] Electron microscopy and mathematical evaluation were conducted on the alloying of St3 steel with Al, Cr, or Ni by surface melting with a continuous 1.4-4 kW $CO_2$ laser to a depth of 0.3-1.0 x $10^{-3}$ m. Evaluation of the extent of mass transfer under the experimental conditions demonstrated that the rate of transfer was predicated on thermocapillary effects, giving figures of approximately 5 x $10^{-2}$ m/sec for Ni and 1.2 x $10^{-1}$ m/sec for Cr, while gravitational forces were not involved. The melt was held within the steel sample by surface tension gradients. Figures 3; references 3: 2 Russian, 1 Western.
[82-12172]

UDC 535.211

ROLE OF NONLINEAR REFRACTION AND ABSORPTION IN MECHANISM OF DAMAGE TO TRANSPARENT DIELECTRIC BY FOCUSED LASER MONOIMPULSE

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 8 Aug 81) pp 11-18

BABADZHAN, Ye. I., KOSACHEV, V. V. and LOKHOV, Yu. N., Moscow

[Abstract] A mathematical analysis was made of the role of nonlinear refraction and absorption in damage to a transparent dielectric by a focused 40-60 GW/$cm^2$ laser beam pulse in the presence of plasma and thermal refraction, and of the thermal breakdown of the dielectric along the beam axis. Beam focusing in the transparent dielectric leads to the development of an avalanche-like propagation of electrons at the plane of focal constriction toward the beam, with the electron concentration behind the wavefront approaching 2 x $10^{13}$ $cm^{-2}$. A heterogenous temperature field develops behind the wavefront with translation of the focal point constriction along the wave

path. The temperature along the beam axis attains the melting point of the dielectric, with the radius of the heated area increasing proportionally with the distance between the electron wave and the focal plane. As a result, the thermoelastic stress in the periaxial field may reach several GPa and, when the focal plane reaches the exit face of the dielectric, a fragment of the surface may be dislodged and ejected. Figures 2; references 7: 6 Russian, 1 Western.
[82-12172]

UDC 539.211

EFFECTS OF GASEOUS ENVIRONMENT ON LASER-INDUCED EROSION OF HIGH TEMPERATURE METALS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 1, Jan-Feb 84 (manuscript received 10 Oct 82) pp 137-138

UGLOV, A. A. and IGNAT'YEV, M. B., Moscow

[Abstract] Experimental studies were made of neodymium laser-induced erosion of high melting point metals (group IV-VI metals) exposed to laser pulses for 1 msec of ~$10^7$ W/cm$^2$ power flux density under an atmosphere of helium or nitorgen + carbon dioxide (1 to 100 atm). Determinations of the mass loss ($\Delta$ M/E) from the target surface showed that the critical pressure leading to attenuation of the effects of the laser was ~10 atm for helium and ~4 atm for nitrogen. The effects of the gases in limiting laser-induced erosion was attributed to the formation of an optically inert dense plasma film at the surface of the metal which acted as a protective barrier to laser penetration. Figures 2; references 8: all Russian.
[82-12172]

UDC: 669.71:539.3822:537.39

INFLUENCE OF SERIES OF ELECTRIC PULSES ON PLASTIC DEFORMATION OF METALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84 (manuscript received 29 Mar 83) pp 587-590

TROITSKIY, O. A., SPITSYN, V. I., academician and MOISEYENKO, M. M., Institute of Physical Chemistry, USSR Academy of Sciences, Moscow

[Abstract] A series of 20 pulses of identical amplitude, $8 \cdot 10^8$ A/m$^2$, and identical frequency, 0.5 Hz, but with length varying from 4 to $20 \cdot 10^{-5}$ s, were used to study the influence of current on plastic deformation of metals. Deformation stress was greatly reduced by application of the pulses. It was found that the current pulses do not participate in actual jumps of deformation, but rather only stimulate the beginning of these jumps. Figures 4; references 10: 8 Russian, 2 Western.
[70-6508]

# IMPROVEMENTS IN UKRAINIAN FERROUS METALLURGY DISCUSSED

Kiev EKONOMIKA SOVETSKOY UKRAINY in Russian No 9, Sep 83 pp 3-12

[Article by D. Galkin, Hero of Socialist Labor and Ukrainian SSR minister of ferrous metallurgy: "Technically Re-Equipping and Increasing the Effectiveness of Ukrainian SSR Ferrous Metallurgy Enterprises"]

[Text] The Ukrainian SSR is one of the primary metallurgical bases of the country. In 1982 the republic's ferrous metallurgy enterprises were responsible for every third ton of finished rolled products, every fourth ton of steel pipe and every second ton of iron ore produced in the USSR. In 1971-1980 the production of pig iron in the Ukraine increased by 12 percent, steel production increased by 15 percent and the production of finished rolled products increased by 10 percent; at the same time, growth in the production of low-alloy and thermal-hardened rolled products increased at a higher rate. Ferrous metallurgy enterprises are undergoing further development through the construction of new, up-to-date metallurgical plants, the renovation and modernization of existing mills, and the replacement of obsolete equipment based on the introduction of the achievements of science and technology.

In 1971-1980 the sector's fixed production capital increased 80 percent. During this decade some unique units were put into operation. They include the country's largest blast furnace with a volume of 5,000 cubic meters at the Krivorozhstal' Plant; the 3600 plate mill, which is the largest in Europe; and the oxygen converter unit at the Azovstal' Plant, which went into operation in 1977. It was built with consideration for the latest achievements of science and technology: the powerful 350-ton units are equipped with control and measuring instrumentation and equipment for automatic process control. It has the potential for the nonfurnace processing of steel using neutral gases, synthetic slag, vacuum treatment (degassing) and powdered reagents. Continuous casting is carried out at machines of the curvilinear type. The following have been opened: a billet mill and the first unit of an electric furnace shop at the Donetsk Metallurgical Plant, the

250-6 mill at the Krivorozhstal' Plant, the 250 rolling mill at the Dneprovskiy Plant imeni Dzerzhinskiy, the mill for the production of large-diameter electrically welded pipe at the Khartsyzsk Pipe Plant, the 140 pipe rolling unit at the Nizhnedneprovskiy Pipe Rolling Plant imeni Karl Libkhnekht, three coke-oven batteries at the Avdeyevka Coke By-Product Plant, as well as new capacities at mining, hardware and refractory enterprises. A large volume of work has been done on the renovation and modernization of existing plants and equipment. Also, a series of measures has been carried out to raise the technical level of the equipment which production units have; to introduce progressive manufacturing processes, mechanization and automation of labor-intensive processes; to improve the quality of output and to save resources.

At the same time, however, the sector operated in an unstable manner in 1981-1982. At the November (1982) plenum of the CPSU Central Committee it was emphasized that ferrous metallurgy was not meeting the plan targets: there was a shortfall amounting to several millions of tons of rolled products which the economy was not receiving. There are many reasons for this situation. They include first of all serious negligence in the organization of production management, a lack of balance among individual production units, the aging of fixed production capital, personnel shortages and reduced demands made for increases in the level of technological and labor discipline; as a result, above-plan downtime for plants and equipment has been permitted and emergency situations have been created.

Since the 10th Five-Year Plan, the sector's enterprises have begun to feel the aging of their fixed capital. The operation of obsolete equipment leads to accidents, losses of output and to increased expenditures for repair work. There are large differences in the technical level of existing units and their technical-economic indicators. Labor productivity at up-to-date plants producing pig iron is 3.5-fold greater than at obsolete units; for steel the figures are respectively 35-40 percent; for reduced billets there is a 2.5-fold difference, and for sheet and plate rolled products it is 3.5-fold. Significant variations are also observed in production costs. The cost of producing pig iron at obsolete units is 23-31 percent greater than at up-to-date ones, for steel the costs are 6 percent higher, for reduced billets they are 14 percent higher, for sheets and plates they are 70 percent higher and for bars they are 60 percent higher.

In accordance with the decisions of the 26th CPSU Congress, the Uk SSR Minchermet (Ministry of Ferrous Metallurgy) worked out a program to raise the technical level of this sector's enterprises based on the process of technically re-equipping, renovating and updating its fixed capital. In the 11th Five-Year Plan the metallurgical workers of the Ukraine were assigned the tasks of

achieving--in addition to an increase in the output of finished rolled products, steel pipes and hardware--a fundamental improvement in the quality and assortment of metal output and accelerated growth in the production of the most economical forms of that output. In order to complete these tasks, the production of pig iron, steel, iron ore and coke must receive corresponding development. One of the basic directions in the work to reach the target set for 1981-1985 is the technical re-equipment of the sector's enterprises, a process which provides for further improvement in the quality of metal output, the intensification of manufacturing processes, a reduction in the material-intensiveness and energy-intensiveness of production, as well as increases in labor productivity and production effectiveness.

The strengthening of intensive factors is demonstrated, first of all, in changes in the structure of capital investment, and this contributes to its more effective utilization. Capital investment for technically re-equipping, renovating and maintaining existing capacities in operational condition will increase by nearly 30 percent; it will amount to 52 percent of the total volume of investment allotted for this sector. In the current five-year plan period these factors and the fuller utilization of internal reserves will provide for an increase of more than 65 percent in the total growth of ferrous metallurgy products to be marketed.

The renovation and modernization of plants and units, including the introduction of up-to-date scientific and technical designs, constitute a general direction in the sector's development. It results from the need to effectively utilize capital investment and to maintain--on this basis--metallurgical units in an appropriate technical state. For example, in the 10th Five-Year Plan an old shop at the Novomoskovsk Pipe Plant was renovated over the period of a year without stopping production. This made it possible to increase the volume of pipe production by 150,000 tons per year. Moreover, expenditures for the renovation amounted to only one-third the capital investment needed to build a new shop of the same capacity. Profits increased more than 1.5-fold. At present nearly all pipes which this unit produces carry the state Seal of Quality. In the sector it has become the norm to combine capital repairs of units with their renovation and modernization.

One of the main tasks in the development of the republic's ferrous metallurgy in the current five-year plan includes the following: further expanding its raw material base, improving the quality of raw iron ore prepartion, maintaining the capacities of existing mining enterprises in suitable condition and bringing the volumes and quality of raw iron ore up to the planned level. At the present time the republic's mining enterprises produce more marketable iron ore than such countries as the USA and Canada taken together. The iron content of the concentrate

produced at iron ore enterprises of the Uk SSR is 1 percent higher than for the country as a whole. However, not all the iron ore which is extracted is subjected to enrichment. At present construction has still not started on a combine for enriching oxidized iron ores in the Kirovograd Oblast due to the lack of domestically-produced highly-effective separators. The plan for technical re-requipment and renovation in the 11th Five-Year Plan calls for mining enterprises to implement a set of measures on the introduction of progressive technology and on the mechanization and automation of production, as well as renovation measures aimed at increasing and at compensating for capacities going out of use.

The technical re-equipment of existing enterprises, including the introduction of new, highly-effective mining equipment and technoloy, will make it possible to increase the republic's output of iron ore by 2.7 percent and to increase the output of concentrate by 11.7 percent by the end of the 11th Five-Year Plan. Renovation work is being carried out at nearly all mining-enriching combines. The partial modernization of the enriching factories of the Severnyy, Poltava, Ingulets and Tsentral'nyy mining-enriching combines has made it possible to increase their capacities by 2.1 percent, 0.9 percent, 1 percent and 15.6 percent respectively.

In 1981-1982 the open mining of iron ore using progressive continuous production line technology increased by 23.5 percent. The underground mining of iron ore using power-driven machines and vibration equipment amounts at the present time to 33.7 percent of the total. In 1982, 4.8 percent more concentrate with an iron content of 65 percent or higher was produced than in 1981. The production of pellets grew by 16 percent in 1982 (in comparison with 1980).

Manganese ore enterprises are being developed by working carbonate ores and shallow strata. In 1984 the development of a major raw-material base for ferrous metallurgy will begin: the Bol'shetokmakskoye deposits will yield manganese ore, reserves of which amount to about 1.5 billion tons. With underground mining of manganese ores, most of the attention is devoted to the construction of comprehensively mechanized mines with flow-line production, which provides for 1.5-2-fold growth in the mines' productivity and the comprehensive utilization of natural resources.

In the current five-year period the demands for quality in the preparation of raw iron ore are increasing. Sintering the burden in a thicker layer is an effective factor in improving the quality of the agglomerate. The average thickness of the burden layer being sintered amounted to 325 mm in 1982 (it was 312 mm in 1980). The sintering units at the Zaporozhstal' and the Yenakiyevo plants have increased the layer to 450 mm, and with

the sintering machinery at the No 10 sintering unit at the No 2 Plant imeni Dzerzhinskiy it has been increased to 400 mm. The introduction of this technology at these plants has by itself reduced production costs by nearly 350,000 rubles due to the improved quality of sintering. The one-time expenditures to bring this new technology on stream will be recovered in a total of five months. However, the broad utilization of the technology for sintering the burden in a thicker layer is held back by the shortage and poor quality of lime and by the inadequate technical level of the exhausters.

The updating of fixed capital has been defined as a very important direction in the development of the by-product coke industry. The implementation of this direction is carried out through the construction of new coke-oven batteries with a total volume of coking chambers amounting to 41.6 cubic meters and the renovation of obsolete coke-oven batteries which show either the same or greater productivity based on the utilization of new technical designs for the improvement of technological conditions, as well as for the mechanization and automation of production processes. In accordance with this direction, plans call for the construction of three batteries (in order to take out of use five worn-out ones) and the renovation of 10 existing batteries.

As a result of the limited nature of coal resources for coking, there is growing significance to the development and introduction of new technologies which resolve the problem of coal resources for coking. It is proposed to introduce on an experimental-industrial scale the production of formcoke from poorly sintering coal at the Bagleyskiy Coke By-Product Plant in the 11th Five-Year Plan. Plans also call for putting into operation installations for the thermal preparation of the burden at the Donetsk Coke By-Product Plant and a ring furnace with a rotary bottom for the production of carburizer at the Krivoy Rog Coke By-Product Plants. Tests are being carried out successfully on the thermal preparation of the coal charge using hot coke, which creates the preconditions for the efficient utilization of heat from incandescent coke and for the improvement of its qualitative characteristics. The Dneprodzerzhinsk Coke By-Product Plant is in the process of bringing on stream a granulator for coal flotation tailings; when it goes into operation, it will resolve the question of how flotation tailings can be used by the economy. The large-scale industrial development of the technology for the production of coke from a partially briquetted burden has been achieved for the first time at the Dnepropetrovsk Coke By-Product Plant; it is being utilized at the Metallurgical Plant imeni Petrovskiy. As a result, the productivity of coke ovens has increased, and the quality of coke has improved substantially in terms of mechanical strength; this has given rise to a 7-8 kg reduction in coke consumption calculated per ton of cast iron.

Because the sintering coal resources are limited, the plans for the technical re-equipment of blast furnace production have concentrated particular attention on the implementation of directions which provide for a saving of coke, and this is a decisive factor in the reduction of production costs of cast iron production. In the 11th Five-Year Plan the reduction in the per unit expenditure of material resources should, according to projections, account for a saving of about 1.5 million tons of coke, and this will reduce material expenditures (by 90 million rubles), demand for coal (by 2.6 million tons) and capital investment (by 90 million rubles). The basic directions in the reduction of coke consumption in blast furnace production include: improving the quality of prepared iron-ore raw materials, reducing downtime and the amount of time the blast furnaces are operating at less than full speed, increasing the blasting temperature and using natural gas, coke-oven gas and coal-dust fuel.

The technology for injecting coal-dust fuel into the hearth of the blast furnace is one of the important directions which provides for fuel savings; it was developed by Don NIIchermet (Donetsk Scientific-Research Institute of Ferrous Metallurgy). At the present time coal-dust fuel is utilized consistently only at the Donetsk Metallurgical Plant imeni Lenin, which has an industrial complex with a capacity of 140,000 tons of coal per year. In 1982 the two blast furnaces at this plant utilized 42,000 tons of coal-dust fuel, replacing 30,000 tons of coke; about 1 million tons of pig iron were smelted with this amount. The plant is conducting work on how to increase the consumption of coal-dust fuel to 60-80 kg/ton of pig iron. The results of extensive operations have established that the factor for the replacement of coke by coal-dust fuel containing 8-10 percent ash amounts to 0.8 kg/ton. The experience of the Donetsk Metallurgical Plant imeni Lenin on the preparation and injection of coal-dust fuel is scheduled to be utilized in the very near future as a technological innovation at other plants, specifically at the Kommunarsk Plant, the Makeyevka Plant imeni Kirov, the Zhdanov Plant imeni Il'ich, the Azovstal' and the Krivorozhstal' plants. A change in the structure of pig iron forms being smelted and a reduction in the smelting of ferromanganese will also contribute to the saving of coke, which is in short supply; the production of ferromanganese requires coke consumption which is 2-2.5 higher than required by the production of conversion pig iron or the smelting of synthetic foundry pig iron.

In 1981-1982 there was a high level of actual effectiveness for the introduction of measures based on the plan for technical re-equipment and renovation. In the agglomeration blast-furnace production of metallurgical plants, nearly 240 measures on the introduction of new equipment have been carried out; in the process the reduction in production costs resulted in a savings of 20 million rubles and the conditional release of 200 em-

ployees. Expenditures for the introduction of these measures will be recovered in 1.2 years. The plan calls for closing down two worn out blast furnaces with a total net volume of 1,093 cubic meters; this will contribute to an increase in production concentration and in the per-unit capacity of blast furnace units.

The plans for technical re-requipment and renovation call for a significant improvement in the structure of steel-smelting production, primarily through the preferential development of oxygen-converter and electric-steel smelting production, which establishes the preconditions for the continuous withdrawal of of obsolete and physically deteriorated open hearth mills, as well as for the improvement of equipment and technology, the broad introduction of non-furnace methods for treating metal and expansion of the scale on which the continuous casting of steel is practiced.

As a result of the renovation of the sector's enterprises and the process of technically re-requipping them and improving the operation of existing units, the smelting of converter steel will increase 1.3-fold in the current five-year plan and the smelting of electric steel will increase 1.5-fold. The following are the basic means for intensification in steel smelting production: a 15-20 percent increase in the intensity with which the metal is blasted with oxygen in converters, a reduction in the charging time as result of preparing the scrap, a 1.3-fold increase in the durability of the lining resulting from an improvement in the technology for converter smelting, improvements in the quality of the refractory materials and the broad introduction of guniting for converters.

Much has already been done along these lines for the development and technical re-equipment of steel smelting production. In 1982 the first unit of an oxygen converter mill was put into operation at the Dneprovskiy Metallurgical Plant imeni Dzerzhinskiy; it consists of two converters with a capacity of 200 tons each. They are to be used for smelting rimmed, semikilled and low-carbon steels amounting to 2.2 million tons per year. The planning and technical designs for the converter mill were adopted with consideration for the possibility of installing a third converter and of making a future increase (up to 250 tons) in the weight of the charge for the purpose of further increasing the mill's productivity. The opening of a new oxygen-converter mill has made it possible to close the obsolete and physically deteriorated Bessemer mill and the No 2 open hearth mill at this plant.

The opening of the following contributes to the intensification of the process: the KAR-30 No 2 air separation unit (with a capacity of 30,000 cubic meters of oxygen per hour) at the Plant

imeni Dzerzhinskiy (1982), the KT-70 unit at the Krivorozhstal' Plant, capacities for improving the preparation of the scrap at the Azovstal' Metallurgical Plant (1981), the Metallurgical Plant imeni Dzerzhinskiy (1983-1984) and the Krivorozhstal' Metallurgical Plant (1983), as well as capacities at 10 enterprises of the Vtorchermet Production Association (1984-1985).

The design of existing steel smelting units is being improved. In 1981 the Zhdanov Metallurgical Plant imeni Il'ich modernized a converter, increasing its volume from 108 cubic meters to 135 cubic meters. At the same time the design of the drive for the converter and the gas cleaning was changed. The implementation of this measure has made it possible to reduce the production costs of output through fixed-constant outlays, to obtain 132,500 rubles of additional profits every year and to increase labor productivity to a level equivalent to the release of 29 people. A similar renovation of the converters was carried out at the Yenakiyevo Metallurgical Plant at a time when capital repairs were being made. In 1982 the equipment of the open hearth furnaces of the No 3 Makeyevka Metallurgial Plant imeni Kirov was modernized (the routes of the gas vents were expanded), as was the equipment at the No 7 Donetsk Plant imeni Lenin, which was converted to natural gas heating. The implementation of these measures provided the opportunity for reducing steel-production expenditures by 216,000 rubles.

The technical re-equipment of steel smelting production and the introduction of progressive technology on a broad scale create the preconditions for saving metal in a subsequent process. As a result of the better utilization of the machinery for continuous casting of billets at the Zhdanov Azovstal' Plant and the introduction of machinery at the Donetsk Plant imeni Lenin, the Dneprovskiy Plant imeni Dzerzhinskiy and the Zhdanov Plant imeni Il'ich, the volume of continuously cast steel will increase 1.7-fold by the end of the 11th Five-Year Plan and will amount to 12.7 percent of the total amount of steel smelted by the sector. As is well known, this method provides for an 8-12 percent saving of metal in comparison with teeming steel into ingots. In 1982 only 7 percent of all steel produced was cast in the continuous manner. The introduction of new capacities for the continuous casting of steel is held back by limited resources for capital construction. For this reason an installation of this kind was introduced at the Donetsk Metallurgical Plant without a number of auxiliary facilities and this makes it impossible to operate the plant at full capacity.

The introduction of technology for heating the head of ingots from killed types of steel and the application of effective thermal-insulating plates in combination with the use of exothermal mixtures provide an average metal saving of 3.5 percent. In 1982, 3.92 million tons of steel were cast with this tech-

nology at the Yenakiyevo, the Azovstal', the Krivorozhstal' and the Zaporozhstal' metallurgical plants, as well as at the Dneprovskiy Metallurgical Plant imeni Dzerzhinskiy and the Nizhnedneprovskiy Pipe Rolling Plant imeni Karl Libknekhta. Nearly 70 percent of the steel produced at 10 metallurgical plants is already being cast using ladle devices without a stopper rod, which ensures a reduction of 1-1.5 percent in the consumption of metal which goes for scrap. At the present time 10 steel casting departments have been converted to this technology, and nearly all the remaining departments of the republic's metallurgical plants have started to bring this type of steel casting to the commercial level.

The non-furnace methods of treating steel, which result in improved quality, will receive broad dissemination. Contributing to this will be the opening at the Donetsk Metallurgical Plant imeni Lenin of a plant for slag-forming mixtures; the use of these mixtures will result in substantial improvement in the quality of metal as well as an increase in the output of serviceable metal amounting to 20 kg/ton of steel. More than 7 percent of the steel smelted in 1982 was subjected to non-furnace processing with neutral gases. The Zhdanov Azovstal' Plant and the Nizhnedneprovskiy Rolling Pipe Plant imeni Karl Libknekht have brought to a commercial level the technology for treating steel with argon in a ladle through a submersible mold; at the converter unit of the Krivorozhstal' Plant the argon is put into the ladle from below during the steel tapping. The application of these technologies results in improved metal quality and additional profits amounting to 150,000 rubles. The Yenakiyevo and Makeyevka metallurgical plants have brought to the commercial level an installation for blowing steel with nitrogen in the ladle. The converter unit at the Dnepropetrovsk Plant imeni Petrovskiy uses technology for processing steel with liquid slag, which is obtained in a cyclone-smelting units. The metallurgical plants of the Zhdanov Azovstal' Metallurgical Plant and the Donetsk Metallurgical Plant imeni Lenin have introduced installations for cycling degassing. However due to design inadequacies the vaccumator at the Azovstal' Plant is not operating under the projected conditions. The manufacturer of the vacuumator (Zhdanov Heavy Machine Building Plant) and the designers (All-Union Scientific Research Institute of Metal Machine Building) have been slow to resolve the questions of how to improve its design and to bring it up to the projected parameters.

In accordance with the technical re-equipment plan, the metallurgical plants are taking measures to improve the molds for ingots and bars, to improve the technologies for the deoxidation and casting of steel, and to expand the utilization of casting lances of a new design in converter plants. In 1981-1982 the steelmaking departments of metallurgical plants carried out nearly 250 measures to introduce progressive technology, as well as produc-

tion mechanization and automation, to modernize and update equipment and to introduce computer equipment. In the process production costs have been lowered by nearly 20 million rubles, additional profits amounting to 22 million rubles have been obtained and about 400 employees have been conditionally released.

The development of rolling production is being carried out by making fundamental improvements in quality and increasing the production of effective types of metal output. The effectiveness of this direction is obvious: it makes it possible to meet metal output needs with reduced expenditures of public labor, to provide significant savings in metal working, as well as to increase the operational indicators for machinery and equipment. The republic's goal-oriented comprehensive scientific-technical program entitled "Metal" has an important role to play in the implemetation of this direction. It calls for plants of the Uk SSR Minchermet to put into operation by 1985 additional capacities for the production of 1 million tons of billets and 1.9 million tons of finished rolled products as a result of the renovation and modernization of existing rolling mills and the opening of new hot rolling mills, including those at the Krivorozhstal' Metallurgical Plant, the Dneprovskiy Metallurgical Plant imeni Dzerzhinskiy and the Zhdanov Metallurgical Plant imeni Il'ich. The plans call for putting into operation in 1983 the first unit of the 3000 plate mill complex at the Zhdanov Plant imeni Il'ich. This will make it possible to close down the obsolete mills at this plant.

The five-year plan called for putting into operation in 1983 the 550 heavy merchant mill at the Dnepropetrovsk Metallurgical Plant imeni Petrovskiy and the first unit of the 3000 plate mill at the Zhdanov Metallurgical Plant imeni Il'ich, with the second unit to follow in 1984. However, as a result of limited funds, the opening of the 550 mill has been delayed until 1985, and the second unit of the 3000 mill has been postponed until the 12th Five-Year Plan. In their annual plans the USSR Minchermet and USSR Gosplan have not set out quotas for construction-installation work in the amounts specified by the five-year plan, and this leads to the dates for the construction and renovation of rolling mills being put off to the following five-year plan.

In 1982-1982 partial renovations were carried out on the 1700 mill at the Zhdanov Metallurgical Plant imeni Il'ich and on the pipe-billet mill at the Dneprovskiy Metallurgical Plant imeni Dzerzhinskiy; and this has made it possible to operate these mills on a more stable basis.

There are also plans to renovate the 350 mill at the Dneprovskiy Plant imeni Dzerzhinskiy, the pipe electric welding shops at the Novomoskovsk and Khartsyzsk pipe plants and the pipe mill at the Nikopol' Southern Pipe Plant. The renovation and modernization

of rolling mills is accompanied by the introduction of progressive technology and measures to mechanize and automate production. In 1981-1982, 360 measures were put into effect in rolling production on the basis of plans for new equipment; they have resulted in the achievement of a yield amounting to 64 kopecks for every ruble invested and in the conditional release of 350 people.

As a result of limited means and the lack of sufficient funds for equipment and spare parts, the updating of rolling mill equipment is being carried out very slowly. At the present time 70 percent of the rolling mills being operated by enterprises of the Uk SSR Minchermet are beyond their normative service life.

Improving the grades of rolled products in general purpose shapes, which make up about 70 percent of the volume of rolled product deliveries, calls for increasing the accuracy of geometrical dimensions, the efficient distribution of metal according to the geometry of the shape and the optimal classification of grade groups. In accordance with the assigned task, one of the most important directions in the implementation of the plan for technical re-requipment is the substantial expansion of production for hot-rolled shapes, which are widely used in machine building and construction, and which provide a 1.5-2-fold reduction in labor expenditures and a significant savings in metal. The Makeyevka Metallurgical Plant imeni Kirov has already brought to commercial level the technology for manufacturing bars with a high level of precision, using calibrating units, application of which gives the consumer an 8-10 percent savings of metal. At the Kommunarsk Metallurgical Plant, the Makeyeka Metallurgical Plant imeni Kirov and the Krivorozhstal' Metallurgical Plant the production of bars with a guaranteed level of mechanical properties, which are differentiated according to strength groups and which provide the consumer with metal savings in amounts up to 10 percent, has been brought to the commercial level for the first time. The production of bars and sheets based on this technology will also be carried out at the Azovstal' Plant, the Dnepropetrovsk Plant imeni Petrovskiy, the Dneprovskiy Plant imeni Dzerzhinskiy. In all, the plans call for the sector to start production in the current five-year period of 85 economical new shapes for rolled products; their use will result in an economic benefit to the national economy amounting to 12 rubles for every ton of new shapes.

Thermal hardening is one of the most economical ways to make a fundamental improvement in the quality of mass-demand types of rolled products made from carbon steel and low-alloy steel. In the process the strength of the rolled products increases 1.5-2-fold, and there is a 10-13 percent saving of metal when machinery is manufactured; in addition, its reliability and service life are increased. Recently a policy has been adopted of

aiming at the thermal hardening of metal in the flow line of the rolling mill. The use of the technology for thermally hardening reinforcing bars of various strength classes has proved very effective. The technology has been developed and the equipment designed for the thermal hardening of shapes.

The plan for technical re-equipment also calls for renovating a metal cord unit at the Khartsyzsk Steel-Wire-Cable Plant and the opening of new capacities at the Zaporozh'ye and Druzhkovka hardware plants, and the Dnepropetrovsk Production Association. The production of brass plated wire will be brought to the commercial level by the Odessa Steel-Wire-Cable Association imeni Dzerzhinskiy. All this will provide for a 30-60 percent increase in the production of various types of hardware, and this, in turn, will create the preconditions for saving metal (up to 30 percent), will reduce labor expenditures (2-3-fold) and at the same time it will require 4-5-fold less production space in comparison with that required for the customer to manufacture this output.

In the current five-year period the comprehensive and coordinated development of ferrous metallurgy in our republic calls for the broad utilization of goal-oriented methods of planning. Among the most important of the comprehensive goal-oriented programs there is the republic's "Metal" Program, which includes 19 basic tasks, including the following: improvements in the structure of steel smelting production and the quality of output; expanded production of rolled products made from low-alloy types of steel; growth in the production volumes of thermally-hardened rolled products and pipes and expanded production of progressive forms of hardware, including those produced by the powder metallurgy method. The fulfillment of the program, given general capital expenditures of about 1.2 billion rubles, must provide a saving of more than 2 million tons of metal in the metal working sectors of the economy by the end of the five-year period; this is 2-fold more than the indicator achieved in the 10th Five-Year Plan.

The goal oriented program entitled "Material-Intensity" has called for Uk SSR Minchermet enterprises to produce rolled products made from carbon steel with a guaranteed level of mechanical properties differentiated on the basis of strength groups. The Makeyevka Metallurgical Plant imeni Kirov, the Yenakiyevo Metallurgical Plant, the Kommunarsk Metallurgical Plant and the Krivorozhstal' Metallurgical Plant are already delivering these kinds of bars, and the Azovstal' Plant and the Plant imeni Dzerzhinskiy are carrying out the appropriate preparatory work. The introduction of this program will make it possible for consumers to make metal savings of 10-15 percent during the manufacture of building and machine parts.

The goal-oriented comprehensive scientific-technical program entitled "Energy Complex" has called for the completion of work to improve the technical base of the fuel-energy complex and to increase the utilization effectiveness of energy resources. The implementation of these programs is coordinated with the better utilization of metallurgical production wastes, the broad application of waste-free and low-waste technologies and other measures aimed at saving all types of resources.

The Uk SSR Minchermet has developed (for the period up to 1990) a program on the utilization of secondary material resources and production wastes covering the entire metallurgical cycle; the program calls for the utilization of iron-containing slurry; the utilization of slurries from mining and enriching combines; the processing of slag from blast-furnace and and steel smelting production units; the utilization of wastes from refractory and non-metalliferous production units, coal-concentrating wastes and graphite-containing wastes which are formed in holding furnaces and installations for the nonfurnace desulfurization of pig iron.

An important role in the acceleration of the growth of production effectiveness has been allotted to the introduction of the program entitled "Labor" at the enterprises of the Uk SSR Minchermet. Plans call for the introduction of 150 mechanized production lines and 42 automated systems for the control of technological processes (ASC TP). The most important ones are an automated system for controlling the process of cutting out rolled products at two lines of the continuous billet mill at the Yenakiyevo Metallurgical Plant, the ASC TP for smelting steel in the oxygen converter unit of the Plant imeni Dzerzhinskiy (1984) and the ASC TP for the slag-refining furnaces and No 1 electric steel smelting unit of the Azovstal' Metallurgical Plant (1983). It is projected that by the end of the five-year plan the number of employees performing mechanized or automated work will be increased to 52 percent and the number of those engaged in manual labor will be reduced to 24 percent; about 9,300 people are to be released for other work.

The further implementation of projects on the technical re-equipment of ferrous metallurgy requires the establishment of a system of methods which will make it possible to resolve methodological questions concerning the evaluation of technical-economic and organizational levels of production which have been achieved, to determine the effectiveness of capital investments, to select systems of indicators and to provide economic substantiation for them, to link the technical re-equipment plan to other sections of the economic and social development plan and to evaluate the influence of technical re-equipment measures on the end indicators of the activities of enterprises, industrial associations and the sector in general.

The implementation of the plans to technically re-equip and renovate the sector will make it possible for the metallurgical workers to increase the utilization effectiveness of the capital investment appropriated for it, to improve its operations and to more fully meet the economy's growing needs for metal.



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FERROUS METALLURGY SAID NOT READY FOR INTRODUCTION OF ROBOTS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 1 Feb 84 p 2

/Article by A. Valentinov, scientific observer of SOTSIALISTICHESKAYA INDUSTRIYA: 'Will Robot Work at Blast Furnace?'/

/Text/ "We intend to introduce 600 robots in the present five-year plan," said M. Malakhov, chief of the mechanization department of the technical administration, Ministry of Ferrous Metallurgy USSR, who paused even to ascertain the impression made. "It is true, just over 100 machines have been introduced to date, but this figure will be increased in the future."

Actually, even for such a branch as ferrous metallurgy 600 robots is a big deal. This is especially true if one takes into account the fact that many enterprises are now experiencing a shortage of workers of basic occupations. In short, I have already pictured how 600 mechanical assistants will appear at blast furnaces, converters, and the output unit of rolling mills. The question remains, however, at which enterprises? In response M. Malakhov handed me an impressive document, an order of the minister dated 30 Jul 81, in which it was clearly written where, when, and in which sector of production automatic manipulators or groups of robots must be introduced. However, familiarization with this document raised doubts in my mind, to say the least.

Judging by this document, neither blast furnace, steel smelting, nor rolling shops need robots. At any rate, they are not mentioned in the order. Where indeed will the 600 planned mechanical assistants work? It turns out that they will be used in repair shops and in the production of consumer goods and other articles. For example, a robotized line is being set up at the NPO Tulachermet /Tula Ferrous Metals Scientific-Production Association/ for the manufacture of shovels, which promises to release 40 workers.

"But you know that these measures will not solve basic production problems!"

"Yes, of course," M. Malakhov agreed, adding: "We tried to raise the question of the use of robots in basic production. However, the subcontracting organizations flatly refused to undertake their manufacture."

The subcontractors are the Ministry of Heavy and Transport Machine Building and Ministry of the Machine Tool and Tool Building Industry, which, in accordance with the accepted division of obligations, should supply the metallurgists with the mechanical assistants. After the publication of the decree of the CPSU Central Committee and Council of Ministers USSR on an increase of the production and introduction into the national economy of automatic manipulators with programmed control (industrial robots) in the years 1981-1985, the Ministry of Ferrous Metallurgy USSR submitted to the machine builders requisitions for the development and production of 54 models of specialized robots. But the Ministry of Heavy and Transport Machine Building agreed to accept only four of these requisitions and the Ministry of the Machine Tool and Tool Building Industry, not a single one.

In the majority of cases workers of these ministries tried to justify their refusals by saying that "methods for a technical solution of the problem are not clear at the present time". This argument, let us say directly, is questionable since any new task starts precisely with a search for possible solutions. The metallurgists could protest fully such arguments and, if need be, shift the dispute with the subcontractors to Gosplan USSR. But, as was explained, its position is quite peculiar. For example, after sending down to the metallurgists the target to introduce 600 robots, Gosplan not only did not designate their suppliers but did not even allocate funds.

"The Ministry of Ferrous Metallurgy itself has undertaken to introduce 600 robots," declared N. Novikov, the chief specialist of the machine tool building department of Gosplan USSR to whom I turned for explanations. But what he said later caused me to doubt the voluntary nature of this "initiative": "We are not preparing to require 100 percent fulfillment of the target from the metallurgists -- the branch is not ready for the introduction of robots at the present time."

If we adhere to this point of view, then much becomes clear: it actually turns the five-year target into good wishes. But we can agree, perhaps, with one assertion: ferrous metallurgy is really not ready for the introduction of robots -- not technically but psychologically. In the branch, or more accurately in its headquarters, it is still not fully understood that wide introduction of robots and manipulators is one of the decisive directions of technical progress.

Nevertheless, when subcontractors refuse assistance there remains not the simplest but a realistic way -- to try to solve the problem with their own resources. With respect to capacity the repair base of ferrous metallurgy is on a par with two medium machine building ministries and the branch has institutes and design buros with much work experience on mechanization and automation. They are entirely capable of producing and testing under the conditions of appropriate production facilities experimental models of the required robots and, by doing this, of depriving the subcontractors of allusions to the complexity of the task.

As far back as 10 years ago the collective of the Dnepropetrovsk Institute NIIAchermet /Scientific Research Institute for Automation of Production Processes in Ferrous Metallurgy/ began the development of robots for production of refractory materials and, on their basis, fully automated lines were developed. The first line was assembled at their experimental plant and later the UkSSR Ministry of Ferrous Metallurgy organized their production. Today around 40 of these lines are already in operation at enterprises.

"But more sophisticated robots are apparently needed for rolling or steel smelting production?" I asked Yu. Goncharov, director of NIIAchermet.

"Powerful machines designed to withstand high temperatures and aggressive media are required here," he answered. "We can no longer get along without such machines. A modern rolling mill is serviced by 10-15 operators and adjusters, whose duties are reduced to guidance and control of the operation of mechanisms. However, from 600 to 1,000 men are engaged in difficult manual work in ad"yustazh, where the products are graded, packed and prepared for transportation. In order to lighten their work our colleagues from a neighboring institute, VNIImekhchermet /All-Union Scientific Research Institute for Mechanization of Production Processes in Ferrous Metallurgy/, have developed robots for binding sheet-metal stacks. But we are now working on a more complex machine for sampling molten steel from converters."

"Who will actually produce it?"

"Such enterprises as Azovstal' /Azov Metallurgical Plant/ and the Novolipetsk and Cherepovets metallurgical combines are cooperating with us. When the robot is developed they will find ways and means to produce it."

This conversation left no doubts: robots are needed in the most responsible sectors of ferrous metallurgy. Despite all difficulties they are already being produced, but by no means on the scale needed. Enterprises are beginning to show an interest but the ministry is managing all these processes poorly. Its technical administration has done very little to unite the efforts of scientists and specialists for solving problems of robotization and in rendering effective assistance to enterprises and has not attempted to arrange close cooperation with scientific and design collectives of machine builders.

The above-noted VNIImekhchermet is the leading institute for robotization in the branch. It was intended to form here a subdivision of 60 scientific associates, who would assume responsibility for coordinating operations and spheres of the application of robots and the development of robotized complexes. However, for the time being this sector has only 10 persons, who barely have time to record incoming documents and prepare information for the ministry.

It is clear that it is difficult to conduct a unified technical policy with such a work force. With respect to assistance to enterprises, this was emphasized graphically in a conversation with M. Kochnev, dep chief engineer of the Magnitogorsk Metallurgical Combine:

"We introduced 10 robots for stamping metalware and there was no question then of basic production. How is science helping us? We concluded an agreement with one of the Moscow institutes with the proviso that the scientists would conduct a survey and give recommendations on where robots should be used..."

"You must admit, Magnitka is by no means a run-of-the-mill enterprise of ferrous metallurgy. If no prospects are seen here, then where exactly are the spheres of application of the forces of branch science?" This is the question I asked Ye. Borisov, chief engineer of the State Institute for the Design and Planning of Metallurgical Plants (Gipromez).

"We envision the utilization of robots in all plans for new production facilities or projects undergoing reconstruction," Yevgeniy Mikhaylovich answered. "But when the ministry coordinates equipment deliveries with subcontractors, not only do the robots disappear from the plans but also other automation equipment. The branch has a number of far more acute current problems on which it is necessary to focus attention..."

"Unfortunately, that is exactly how it is," confirmed S. Kolpakov, first deputy minister of ferrous metallurgy. "Many of our enterprises have an acute need for renovation of basic equipment. Aware of the limited possibilities of the machine builders, we are often forced to agree to a minimal level of automation and mechanization although, if we think about the future, we should not do this..."

One cannot help agreeing with this conclusion. The automation of processes in ferrous metallurgy, including with the help of robots, requires the greatest of attention. I would remind those who today do not wish to understand this of the words of Comrade Yu. V. Andropov: "We must persistently concern ourselves with the solution of problems of mechanization and automation of production also because of their sociopolitical significance. The fact is that a man delivered from hard, tiresome manual labor manifests, as a rule, even greater initiative and responsibility for assigned work."

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## IMPROVED MINERAL RESERVE CLASSIFICATION INTRODUCED

Moscow PLANOVOYE KHOZYAYSTVO in Russian No 2, Feb 84 pp 83-86

[Article by A. Bybochkin, chairman of the USSR State Committee for Mineral Reserves, and A. Petrenko, chief specialist of the USSR State Planning Committee: "Improving the Economic Validity of the State Balance of Mineral Reserves"]

[Text] In the USSR, the earth and its mineral wealth are the property of the Soviet state. The country has developed a system of normative documents which determine the conditions for geological exploration, joint geological-economic evaluation and systematic use of mineral reserves. This allows the consideration of alternate distributions of the extractive sectors of industry and guarantees the necessary levels of their proportion and development. The growth of capital-intensive extractive industries entails the overcoming of a number of unfavorable factors such as imperfections of the economic mechanism, the sometimes low level of production technology, etc.

Characteristic of the present level of the country's economic development are substantive shifts in the distribution of production, primarily in the extractive industries; the opening of new areas in the North and East; and the introduction of new mineral sources into the economy. The broadening scale of raw material use, accompanied by a natural decrease in quality, an increase in mine depth, increasing expenditures for the protection of labor and the environment and other factors, have increased mineral extraction and processing costs, raising the value of mineral raw materials. The continual growth of mineral raw material use in the economy is accompanied by an increase and accumulation of unused waste products and the unbalanced (incomplete) use of a number of basic and valuable by-products. All of this makes scientifically based state evaluation and creation of conditions for the effective use of raw materials more important. It requires that all enterprises, organizations and citizens exercise care when using mineral wealth.

At present, raw materials make up two-thirds of the cost of a unit of production. This circumstance demands the fullest use of the natural potential of each deposit and the lowering of the cost of production. It also increases demands on the geological, technological and economic validity of minearl resource reserves and on their complex accounting. A solution to the urgent problems of mineral base development and the efficient use of

raw materials is impossible without complete and reliable information about the quality and quantity of mineral reserves, their composition, production and refining process technology and geological and hydrogeological exploitation conditions.

The aggregate accounting of these factors and their economic evaluation are critically important in improving the quality and validity of the state balance of mineral reserves and the quality and validity of the mineral reserves in the state balance, in properly reflecting reserve dynamics in the state balance and in directing the efficient use of these reserves.

Therefore, along with the rapid growth of mineral raw material consumption and the greater complexity of locating and exploiting deposits, problems arise in the following areas: mineral resource protection, the search for ways to satisfy mineral raw material demand, their efficient inter-enterprise use and the expanded use of local raw material resources.

A reliable base for organizing the full state accounting of mineral reserves under present conditions must be a scientifically (geologically, technologically and economically) based classification. The use of such a classification system with clearly defined categories permits a more correct reflection in state balances of the true state of mineral reserves of separate economic regions and industrial complexes. It permits the evaluation of the fulfillment of current and future mineral raw material demand and the determination, on the basis of a common criterion, of the degree to which the mineral raw material base has been evaluated and proven. This permits the planning of future industrial development and prospecting work in various regions of the country. The universal and full use of classification for estimating and evaluating mineral reserves will facilitate an increase in the intensity of public production. It will increase the geological and economic effectiveness of prospecting efforts and will aid the efficient use of resources.

What is the initial basis of such an accounting and how do the basic government balance documents conform to the classification system and to the accounting data of reserve classification?

The classification of solid-mineral deposit reserves which existed until recently was adopted in 1960. It facilitated the scientifically based evaluation of the mineral raw material base for such important sectors of the economy as ferrous and non-ferrous metallurgy, the coal industry and the building materials and mineral fertilizer industries. Present solid mineral reserves in the state balance were estimated and proven with a high degree of reliability using this classification. It served as a model for the present solid-mineral reserve classifications used by the CEMA, which were developed in accord with the general conditions and principles of categorizing reserves which are used in the Soviet classification system. When United Nations organizations developed an international reserve classification system in 1975, it was similar to the Soviet classification categories. Much of the accepted terminology in international reserve classification is derived from the Soviet system. However, the need arose to improve the systematic classification of deposits and the accounting of their reserves.

In accordance with the Basic Law of the USSR and the union republics on mineral wealth, additional uniform principles have been developed for calculating and accounting for the proven level of mineral reserves, their economic value and the degree to which they are ready for industrial development. The USSR Council of Ministers has developed and approved a new mineral resreve classification which preserves the principles of the previous system (1960) of categorizing reserves by their economic value, the degree to which they have been geologically studied and proven and the profitability of their use. Besides these, the new system contains very substantial additions and changes aimed at further improving the quality and effectiveness of exploration, the reliability of proven reserves and their estimation and preparation for complex industrial development. The classification system also takes account of the regulations of the Basic Law on the confirmation of conditions and the conditions for developing deposits. It takes account of the procedures for designing mineral extraction and refining enterprises, matters of preserving mineral wealth, state accounting of reserves and mineral deposits, the procedures for confirming reserves, etc.

The new classification system gives increased attention to the geological and economic evaluation of deposits and to the economic evaluation of proven reserves, both commercial and non-commercial. It specifies the criteria for classifying reserves as A, B. $C_1$ and $C_2$, depending on the degree to which they can be proven and to which they have been studied from geological, technological, mining and hydrogeological standpoints. The classification system determines normative ratios of various categories of proven reserves for the planning of industrial enterprises. It stipulates the use of category $C_2$ reserves in the design of mining enterprises. It develops conditions for determining the state of preparation of a deposit for development, for reducing lead times and expenditures on detailed surveying of deposits and for significantly increasing their potential.

The new system is based on modern scientific thinking about the Earth and on achievements in the technology and organization of the extraction and complex refining of mineral raw materials. It takes into account the need for worker safety in exploring and developing deposits and for environmental protection.

Fulfilling the requirements of the new reserve classification system and the full accounting of reserves in the state balance will undoubtedly help increase the reliability of reserve estimates.

This will further improve the geological, technological and economic content and structure of state reserve balances and will improve the accounting of all types of proven reserves in each deposit.

The changes in the classification system will significantly broaden the information available on mineral reserves. Most importantly, the changes will facilitate the differential estimation of reserves with regard to different profitability levels of development and regional distribution. They will provide a firmer basis for estimating the capital investments needed to jointly or separately develop proven deposits.

The differential approach to accounting proven reserves in the state balance, based on the new classification system and taking into account modern demands on production intensification, together with the use of information in development and condition confirmation documents, will provide a better base for determining the potential of proven mineral reserves and their economic structure. A better base for making deposit development decisions will be provided. At present, the economic information contained in development and condition confirmation documents has not been sufficiently utilized in compiling the state reserve balances.

The present structure of state balances still does not meet the growing demands of the directive and planning agencies for the development of basic industrial sectors, nor does it conform to the decisions of the November 1982 CPSU Central Committee plenum. Their decisions were aimed at increasing the role of state accounting and control and strengthening the complex use and economy of resources. The state balance structure does not reflect the full extent of proven reserves by production unit.

At present, the state balance accounts for the useful components of complex non-ferrous deposits in different sector balances: copper, lead and zinc, gold, silver, sulfur, phosphorous, etc. This narrow approach does not meet the requirements of planning agencies. Noble metals in complex ores are accounted for without subdivision into reserves of extractable and non-extractable minerals in the concentrate. Reserves are also included which presently have no prospective value due to the lack of effective technologies for extracting by-products.

The state balance of mineral deposit reserves needs basic improvements and must reflect the aggregate potential of each deposit. It must do more than just determine separate components of complex ores and other raw materials by industrial sector balances. The compilation of aggregate balances along with sector balances will provide, in our view, the necessary legal basis for increasing the responsibility of design institutes and mining sector ministries and enterprises to make full use of proven reserves on an efficient economic basis.

Besides reserves of basic components and by-products, the reserves of other types of raw materials and waste rock for the chemical and construction industries will be included in the geological-economic estimation of the overall protential of deposits and their proven reserves. They will also be used to determine to which balance the deposits belong. This will allow a more efficient distribution of extractive enterprises independently of their departmental affiliations. There are many examples where the lack of complex accounting in the state proven reserves balance has negatively affected the complex development of a deposit. For instance, one industrial gold deposit in Kazakhstan would not be included in the balance without accounting for the extraction and refining of overburden.

The same can be said about a number of other deposits of valuable minerals, the reserves of which enter the balance only if by-products--crushed stone and other rocks produced by mine development--are utilized. The inclusion

of reserves in different balances under different names decreases the effectiveness of raw material use. Deposits are not then considered as a whole. This hinders the abandonment of the departmental approach to the use of minearl resources and leads to waste.

Typical examples,in particular, are the Kola apatite-nepheline deposits and a number of complex iron-ore deposits in the Urals and other regions, whose placement in the balance is determined by the possibilities of their complex development. This has been repeatedly discussed in the press. Extracting from these ores and refining only the basic apatite or iron concentrates will not ensure the profitability of these deposits in the future and will lead to an unwarranted increase in costs. The separate accounting in the state balance of non-ore and other minerals weakens the attention of design organizations and the corresponding ministries to the problems of: 1) the complex use of such ores and overburden, 2) the creation of many departmental open pit mines for construction and other materials, 3) the significant waste of raw materials and 4) environmental pollution.

A positive example of the complex use of ore is the Almalyk Mining-Metallurgy Combine in the Uzbek SSR. Along with the production of non-ferrous metals and sulfuric acid, it has produced significant revenue from overburden (loess soils), which is used to recultivate eroded agricultural lands.

In compiling the state reserve balance, the direct revenues from using specific types of minerals and the maximum quantity of valuable by-products must be considered.

The same may be said about accounting for reserves of complex oil and gas deposits, especially those containing valuable by-products--gas condensate, sulfur, ethane, propane, butanes and metals--as well as pickling solutions and industrial waste water, the complex use of which will increase the intensification and effectiveness of the economy. Of great significance in improving state reserve balance quality is the confirmation of current reserve estimates put in the balance by ministries. Experience with examining reserve estimation documents has shown that there are cases where the current reserve estimates are significantly higher than those presented to the USSR State Committee for Mineral Reserves for confirmation. Besides this, in-house reserve estimates are not always confirmed by examination. If current reserve estimates are to be included in the state balance, then it is necessary to clarify the conditions on which the calculations are based. In a number of cases, in-house reserve estimates presented to the USSR State Committee for Mineral Reserves were lowered for that reason by as much as two-thirds, compared to the figures in the state balance. In our opinion, the state reserve balance should reflect not only the quality and the quantity estimates of reserves, but also their economic character, including reserve structure by deposits, groups of deposits, by economic regions and by union republics. Specifically, state oil and gas reserve balances should reflect a number of indices which define the economic structure of the oil and gas raw material base: the type of deposit, oil quality (viscosity and other properties under formation and standard conditions), the type and permeability of the reservoir rock, reservoir depth, the degree to which developed reserves have been

depleted, the expected cost of extraction, the oil recovery factor based on technical-economic confirmation data and etc. It is advisable that the ministries concerned (USSR Ministry of Geology, USSR Ministry of Ferrous Metallurgy, USSR Ministry of Non-Ferrous Metallurgy, Ministry of the Petroleum Industry, Ministry of the Gas Industry, USSR Ministry of the Construction Materials Industry, Ministry of the Chemical Industry and Ministry of Mineral Fertilizer Production), the State Committee for Science and Technology and other departments carefully review problems of improving the state mineral balance in order to make it technologically and economically more firmly based. They should improve its quality and increase the role of state reserve accounting and also increase the potential of natural resources.

This to a great degree will determine the further growth of production and the development of productive forces based on the complex use of mineral and other natural resources and the application of the progressive achievements of science and technology. Therefore, it is advisable, for the good of the economy (by reducing waste, stopping the inefficient use of resources and increasing the return on investments) and to strengthen cost-accounting relationships, to perfect the geological-economic estimation of explored reserves of deposits and their complex accounting in the state reserve balance. The implemented Temporary Standard Method of Estimating Mineral Deposits meets this demand. With this method, the state reserve balance will have to contain a more complete and complex economic estimate of mineral reserves.



12595
CSO: 1842/83

# PROBLEMS IN POWDER METALLURGY AT ZAPOROZHYE

Moscow RABOCHAYA GAZETA in Russian 12 Jan 84 p 2

[Article by the editorial staff of INDUSTRIAL'NOYE ZAPOROZHYE and correspondent collective of RABOCHAYA GAZETA: "Troublesome? But Necessary! Problems in the Introduction of Powder Metallurgy at Zaporozhye Enterprises" under the heading "Metal Is Industry's Bread"]

[Text] How to produce a part without further mechanical treatment--the old dream of a manufacturing engineer and a manufacturer--is becoming more of a reality today. Thus, a number of enterprises of the Zaporozhye Oblast have already recognized the advantage of advanced technology using iron and titanium powders.

For the first time in the industry, a production section was established at the Motorostroitel' [Motor Building] Association. Automatic and semiautomatic machines are used for pressing the parts, the caking is done in furnaces with a protective atmosphere and in a vacuum. There is equipment for a closed process. Approximately 150 descriptions of basic production parts are being serially manufactured at the section, and it is being planned to introduce 80 more.

Powder metallurgy makes it possible to solve a wide variety of production problems. A problem with the production of tool electrodes occurred at the association in connection with the development of electrophysical treatment of metal. The motor builders were convinced that [tool electrodes] made of powder materials turn out to have complex geometry and a high degree of precision.

At the present time, machine builders are manufacturing 95 types of tool electrodes. They are used to making grooved holes in parts made of materials that are hard to process and precision stampers. Yearly economic savings have exceeded 150,000 rubles.

This is the second 5-year plan period that the Berdyansk Yuzhgidromash [Southern Hydraulic Machine] Plant has dealt with powder metallurgy. Here they have availed themselves of only one branch of this advanced technology: the production of antifriction materials.

"This choice," explains the foundry chief at the plant A. L. Mavrodiy, "was determined by the fact that there are many 'runner hub' type parts that work

as bearings in the pumps manufactured by Yuzhgidromash. Operating difficulties were aggravated by the fact that they are placed in water."

The creative cooperation between the industrial workers and the scientists of the Institute of Problems of Metallurgy of the Ukrainian SSR Academy of Sciences led to the establishment of the powder metallurgy section at the plant. What did this result in? If, for example, previously a 30-millimeter-size part was made from a 35-millimeter diameter piece of stainless steel and required nine mechanical treatment processes for this--boring, drilling, broaching, and polishing, etc.--now an article made of powder requires only boring and polishing.

Hard alloy upsetting materials that are produced by the caking method have already been used at the Kommunar Motor Vehicle Plant for many years. Fifty-seven types of motor vehicle parts are produced today using them. The efficiency of using hard alloys can be seen in such examples. The life of the tools increased from 10-20,000 strikes up to one million. The steel die which reduces the housing pin formerly lasted a maximum of two shifts. Now it lasts up to one year and four months.

Manufacturing parts from titanium alloys by powder metallurgy methods should be looked at especially closely. And the matter does not lie so much in the properties of titanium itself. In Zaporozhye, the Institute of Titanium and the Industrial Scientific-Research Laboratory for Pressing and Stamping Nonferrous and Rare Metals by Powder Metallurgy Methods in the Zaporozhye Machine-Building Institute imeni V. Ya. Chubar' make up the solid scientific-research base that is called upon to develop this direction of scientific-technical progress.

With the mutual interest of scientists and industrial workers, such cooperation is highly effective. N. N. Yurchenko, the shop chief of the Motorostroitel' Association, cites such an example.

The joint work with the Institute of Titanium made it possible to introduce a powder alloy in which the mechanical properties are analogous to titanium. Today 38 types of parts are produced from it, with a coefficient of metal use of up to 0.9.

Five authorship certificates have been issued for a hydrostat. Citing this fact, one of the authors of the apparatus, V. A. Pavlov, chief of the laboratory, notes not without bitterness: "It looks as if there is no need today to persuade any of the industrial workers to favor powder metallurgy; everybody is for it. But not many introduce it."

It is hard not to agree with him. A high-voltage equipment plant in Zaporozhye could be added to the enterprises that we have already named. Last year work started here on using powder metallurgy in manufacturing flange and runner hub type construction parts.

Unfortunately, the list of enthusiasts ends with this.

Are the potentials of this advanced technology being used to the full extent in, let us say, the Kommunar Motor Vehicle Plant? Not at all. Several years ago, the Zaporozhets Educational-Scientific-Industrial Association, which included the Zaporozhye Machine Building Institute and the motor vehicle plant, was organized. Within its scope, it was planned to conduct work to introduce powder metallurgy in three directions. A press for producing parts was developed by the laboratory specialists directed by V. A. Pavlov. It still remains to manufacture it...at Kommunar. More than three years have past since that time. But no headway has been made in that matter.

At the same time at the plant an order was issued to establish a special powder metallurgy section, and it was planned to use up to 10 metal powder articles in a motor vehicle. But this resolution also remains only a good intention.

"So far," admits G. I. Stepanov, an associate of the Main Design Administration, "we still don't have close creative and practical ties for introducing powder metallurgy with the Zaporozhye Machine-Building Institute imeni V. Ya. Chubar'."

The work is impaired: In motor vehicle model ZAZ 968M presently being produced, only four parts (with a combined weight of 1.2 kilograms!) are manufactured with the use of powders.

And this is how A. V. Alekseyenko, the chief engineer of the Berdyansk Dormash [Repair of Road Machines] Plant, answered the question: "How is powder metallurgy being used?": "For now, not at all. It is possible, of course, to do much [with it]. There is such an idea: to set up a small section in the heat department for powder. But it is still just an idea."

This question is completely natural: Are they not pondering too long at Dormash? After all, at a similar enterprise, the Bryansk Road Machine Plant--incidentally under the same ministry--articles made of powders are being used successfully. Well, but Yuzhgidromash is even closer.

The reluctance of the technical services cited and of many other enterprises to introduce powder metallurgy is explained simply by the force of inertia, the fear of the new, the habit of thinking with settled ideas and treating metal carelessly.

And it is no accident, therefore, that in the decree of the Melitopol'kholodmash [Melitopol Refrigeration Machinery] Production Association's open party meeting devoted to the results of the June (1983) plenum of the CPSU Central Committee, the communists called for the managers of technical serves to adopt effective measures to introduce substitutes for metal by putting a powder metallurgy section into operation.

The objective causes hindering the introduction of advanced technology must also be taken into account. The manufacturing of new parts by the method of caking powders is often delayed because of the lack of press molds, its materials, and its technology. The leading institute--the Institute of

Problems of Materials Science of the Ukrainian SSR Academy of Sciences--obviously must energetically undertake to solve this problem and develop standard designs for making press molds, recommend durable, economically sound materials and the advanced technology for manufacturing them, including electrophysical processing methods.

The weak point continues to be caking the parts in a protective atmosphere. In the Motorostroitel' Association, for example, it is carried out in batch furnaces. In the opinion of the industrial workers, it is necessary to have continuous units with a protective atmosphere that would make it possible to reduce labor-intensiveness, save electric energy, and improve working conditions with high standards of production.

The Ministry of Electrical Engineering Industry is in charge of an organization to produce these furances. In this year's plan, only experimental models are to be manufactured; it is not known when series production will be organized.

There are still considerable difficulties caused by late delivery of powders and their unstable quality. It appears that in the USSR Ministry of Nonferrous Metallurgy more attention should be paid to its industrial laboratory. Its equipment does not stand up to any criticism.

The solution to all these problems will be to promote more energetic and widespread introduction of the new advanced technology, to meet the demand of the December (1983) plenum of the CPSU Central Committee to raise the economic operation level, to accelerate scientific-technical progress, and to utilize more fully production potential and material, labor, and financial resources.

12478
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# PHASE EQUILIBRIUM OF Ti-Al-Mo-Zr ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 15 Feb 82) pp 215-221

NARTOVA, T. T., TAROSOVA, O. B. and NOTKIN, A. B., Moscow

[Abstract] A study is made of the phase equilibrium of alloys adjacent to the titanium point of the tetrahedron in the quaternary system Ti-Al-Mo-Zr on a cross section with constant zirconium content at 3%, variable aluminum content from 0 to 16% and molybdenum content 0 to 5%, on three isothermal cross sections at 1100, 900 and 600°C. The purpose of the work was to study the influence of the addition of molybdenum at up to 5% and zirconium at up to 3%, most frequently used in commercial titanium alloys, on the position of the grain boundary between the phase areas in question. The charge material was iodide titanium, iodide zirconium, sheet molybdenum, high purity type A-999 aluminum. Pressed 15 g specimens were melted by crucibleless induction melting in the suspended state in purified helium. Cast specimens sealed in evacuated quartz ampules were annealed in stages at 1200-600°C over a period of more than 1700 hours. The results were used to construct iosthermal cross sections at 1100, 900 and 600°C. Microstructural studies revealed that the solubility of molybdenum in the α phase increased upon alloying with aluminum, while the quantity of β phase decreases. The α phase begins to segregate at a lower aluminum content than in the binary system Ti-Al. Figures 4; references 17: 11 Russian, 6 Western. [65-6508]

UDC 669.295:620.1

## CONNECTION OF CRYSTALLOGRAPHIC TEXTURE AND ANISOTROPY OF FLOW EXTREME OF TITANIUM ALLOY LEAVES

Moscow TSVETNYYE METALLY in Russian No 2, Feb 84 pp 77-79

SEREBRYANYY, V. N. and KOKNAYEV, R. G.

[Abstract] Anisotropy of mechanical properties, especially flow extremes in metals and alloys with hexagonal structures, is determined by crystallographic texture. Zaks and Taylor previously used direct and reverse polar figures to evaluate this anisotropy, and others used the function of orientation distributions to assess flow extreme anisotropy. The present article reports on study of leaves of VT1-0 and VT5-1 titanium alloys using this method. Data on tension of flow with a single-axle load are analyzed mathematically for hot-rolled leaves. Results confirmed the correlation between calculated and experimental data with angles $\leq 60°$, but factors other than crystallographic texture seem to play a more important role where greater angles are present. Figures 2; references 10: 4 Russian, 6 Western.
[81-12131]

UDC: 621.762.669.295'94

## STRUCTURE FORMATION OF TITANIUM-NICKEL EUTECTIC ALLOY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 1, Jan 84
(manuscript received 28 Dec 82) pp 66-71

CHEPELEVA, V. P., DELEVI, V. G., KIZIKOV, E. D., TRUNEVICH, L. V. and CHEREPENINA, Ye. S., Institute of Superhard Materials, Ukrainian Academy of Sciences

[Abstract] A study is made of the mechanism of structure formation in a eutectic titanium-nickel alloy, the degree of wetting of superhard materials by the alloy is determined and the possibility of creating diamond-containing composites is studied. Powders of nickel and titanium in the eutectic ratio were mixed in a laboratory mixer, pressed with the addition of a plasticizer and sintered in a vacuum at 1223-1323°K for 0.25-1.56 hr to assure sintering in the presence of both solid and liquid phases. The structures of the specimens are discussed. The structure formation mechanism of the alloy consists of dissolution of nickel particles in the titanium matrix forming the TiNi intermetallic compound, generating pores, followed by a transition to $Ti_2Ni$ and the appearance of liquid at the $\beta$-Ti-$Ti_2$-Ni interface, which crystallizes as a eutectic at 1228°K or undergoes eutectoid decomposition at below 1043°K. The alloy produced is highly compact, strong and hard. The contact wetting angle with diamond is about 72° when heated to 1523°K. Figures 5; references 7: all Russian.
[64-6508]

UDC: 621.762

TITANIUM-BASED ANTIFRICTION MATERIALS (Review)

Kiev POROSHKOVAYA METALLURGIYA in Russian No 1, Jan 84
(manuscript received 20 May 83) pp 80-90

RADOMYSEL'SKIY, I. D. and MANUKYAN, N. N., Institute of Material Science Problems, Ukrainian Academy of Sciences, Yerevan Polytechnical Institute

[Abstract] A review of the literature on titanium-based antifriction materials is presented. Some 80% of titanium currently produced is used as corrosion-resistant materials, 20% as structural materials. This is largely a result of the lack of broad-scale studies designed to improve the antifriction properties of titanium, seriously hindering the introduction of these materials for use in friction couples. The use of mineral oils for lubrication of titanium is not promising. Various approaches have been developed to improve the antifriction properties of titanium, including diffusion saturation with oxygen, nitrogen, carbon, boron, silicon and other elements, metallization by galvanic and chemical methods, gas-phase precipitation, etc., and the application of coatings by atomization. Surface hardening is suitable only for mild friction conditions. Work in the area of powder metallurgy of titanium has confirmed the possibility of creation of a new class of titanium alloys with good antifriction properties. Metal-polymer composites consisting of a porous metal framework saturated with a polymer are quite promising in this respect. The technology of manufacturing these materials includes mixing of metal powders, their pressing and sintering, saturation of the porous framework with polymer composites, and mechanical working. References 53: 50 Russian, 3 Western.
[64-6508]

UDC: 669.295.5-786.977.018.8

KINETICS OF NITRIDING OF TITANIUM ALLOYS AT 1173°K

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 19, No 6, Nov-Dec 83 (manuscript received 16 Mar 83) pp 33-35

FEDIRKO, V. N. and POGRELYUK, I. N., Institute of Physics and Mechanics imeni G. V. Karpenko, Ukrainian Academy of Sciences, L'vov

[Abstract] An attempt is made to evaluate the role of alloying elements in the nitriding of the commercial titanium alloys VT1-0, VT5-1, PT7-M, OT4-1, VT6s and VT-32 in pure nitrogen at atmospheric pressure and 1173°K for 1-100 hours. The specimens were preliminarily electropolished, degreased, washed and annealed for 1.5 hours at 873°K at a residual gas pressure of $1.3 \cdot 10^{-3}$ Pa. The microhardness of the near-surface layers showed a clear tendency to decrease with increasing distance from the

surface into the depth of the specimens. With increasing nitriding time, surface microhardness of all specimens increased approximately parabolically, reaching the maximum value at 100 hours for OT4-1, the least value for VT-32. The thickness of the hardened layer was generally proportional in the square root of nitriding time, 230 μm at 100 hours for VT6s, 180 μm for VT1-0, 160 μm for OT4-1, 95 μm for VT5-1 and 70 μm for VT-32. Thermogravimetric studies confirmed the parabolic variation of the nitriding process. The process thus forms a contact layer of nitrides on the surface of the alloys under the experimental conditions. The quantitative and phase composition of the surface layer changed with nitriding time. Figures 2; references 6: 3 Russian, 3 Western.
[54-6508]

UDC: 669.296-122.2:548.735.6

INFLUENCE OF TRANSVERSE COLD ROLLING ON TEXTURE OF PT-3V TITANIUM ALLOY

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 9 Aug 82) pp 62-64

ADAMESKU, R. A., BUNIN, L. A., GREBENKIN, S. V., YEFREMOV, V. I., SKRYABIN, D. A. and SHISHMAKOV, A. S., Sverdlovsk

[Abstract] Rectangular plates of alloy 40 x 250 mm were test rolled with the long side of the rectangle transverse to the direction of hot rolling. Test rolling was performed at room temperature in the direction transverse to the direction of hot rolling on a mill with rolls 320 mm in diameter. The maximum compression used was about 30%. Strips were produced with compressions of 5, 10, 15, 20, 25 and 29%. Texture specimens were disks 30 mm in diameter pressed out of the strips. Texture was studied by analyzing direct band figures obtained on an x-ray diffractometer in copper radiation. Cold rolling of 5% does not significantly change the texture of the strips. Deformation of 10% increases the intensity of the (0001)$\pm\phi$NN-R, where N is the direction normal to the surface, R is the direction of rolling and significantly decreases the slope angle of the base plane $\phi$. Further increases in deformation lead to an increase in the orientation and decrease in scattering, particularly about the transverse direction. A relationship between crystallographic texture and mecahnical properties is noted for the alloy tested. Figures 3; references 3: all Russian.
[65-6508]

UDC 669.295'292:621.785.78

EFFECT OF AGE HARDENING AND LOW TEMPERATURES ON INCOMMENSURATE STRUCTURE AND RESISTANCE OF TI-23 At.% V ALLOY

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 57, No 1, Jan 84 (manuscript received 30 Dec 82) pp 189-191

D'YAKONOVA, N. B. and LYASOTSKIY, I. V., Institute of Precision Alloys, Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] Alloys of titanium with transitional metals stabilizing the matrix and electron concentrations above ~ 4.2 el/atom in tempered states are characterized by irregular incommensurate structures. The authors compared structural changes occurring at reduced temperatures and low-temperature annelaing to determine the effects of thermal processing on temperature dependencies of structure and resistance. The Ti-23 At.% V alloy tested had a typical structure for such compositions. Data on temperature and resistance are given. Results showed that the quantity of atoms did not vary by more than a factor of 1.3 following cooling and age hardening of the tempered alloy. Age hardening stabilized the incommensurate structure, and low-temperature thermal processing made it possible to alter its parameters and properties, while high-temperature processing brought disintegration of the omega-phase. References 8: 4 Russian, 4 Western.
[73-12131]

UDC 669.295'788:539.4.015

HYDROGEN PLASTIFICATION AND HYPERPLASTICITY OF TITANIUM ALLOYS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 57, No 1, Jan 84 (manuscript received 16 Jul 82, after revision 15 Feb 83) pp 175-183

KOLACHEV, B. A. and NOSOV, V. K., Moscow Institute of Aviation Technology

[Abstract] Previous studies had clarified the beneficial effect of hydrogen in hot deformation of titanium alloys, including stabilization of the plastic beta-phase at lower temperatures, suppression of brittleness in the intermetallide alpha$_2$-phase, increasing the diffusion component and production of new creep systems. The authors studied changes in the state of phase composition in relation to variations in hydrogen at phase-transition temperatures where hyperplasticity is most commonly encountered (850-1100°C for various industrial alloys with low rates of deformation and stable granular structure with 2-10 mkm granule size). Hydrogen was found to reduce the temperature of alpha$_2$ + beta/beta transformation significantly in titanium alloys. Hydrogen plastifiers were most effective for structural preparation and subsequent deformation of highly heat-resistant alloys with intermetallide hardening. Analysis of temperature dependencies of flow tension in titanium alloys with hydrogen allowed confirmation of the hypothesis that

rapid decline of temperature dependency changes to a gradual decline in durability of alpha- and beta-phases. Details of temperature functions are discussed. Structural factors and degree of alloying also play roles in determining deformation-temperature relationships. Figures 5; references 29: 24 Russian, 5 Western.
[73-12131]

UDC 669.295.3.041:53

METHODS FOR LENGTHENING SERVICE LIFE OF HEATERS OF VACUUM FURNACES FOR SEPARATING SPONGE TITANIUM

Moscow TSVETNYYE METALLY in Russian No 2, Feb 84 pp 57-58

PUTINA, O. A., PUTIN, A. A., VASEVA. L. I. and SHABALINA, O. B.

[Abstract] Vacuum electric resistance shaft furnaces with 80% Ni and 20% Cr heaters are used for separating the reactive mass in magnetic thermal production of porous titanium. Overheating of such heaters leads to poor quality titanium and increased power and labor utilization, as well as reduced productivity and furnace heater life. The present article reports on the effect of linear seam failure and subsequent loss of sealing of furnace seams. The tested furnace was made of 12Cr18Ni10Ti steel. Poor seams showed up within five production cycles, and their number increased greatly by the end of 20 cycles, apparently due to the effects of the 1000°C temperatures involved in production. Seam failure was particularly common in the shaft area. It was recommended that protective flanges be made only of the CrNiTi steel, but some corrosion problems remained. Varying procedures for drying the furnaces after major overhauls were tested. It was found that magnesium chloride remaining on furnace surfaces was a major factor in corrosion and failure. Design changes and cleaning procedures are recommended based on these findings. References 4: all Russian.
[81-12131]

UDC: 669.018.1

ISOTHERMAL CROSS SECTIONS OF SYSTEM Nb-Ti-Al AT 1200-600°C

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 15 Mar 82) pp 200-202

ZAKHAROV, A. M., KARSANOV, G. V., TRONTSKIY, B. S. and VERGASOVA, L. L., Moscow

[Abstract] A study is made of the phase composition of alloys in the system Nb-Ti-Al at 1200-600°C on the cross sections between the trinary $\gamma_1$ ($TiNbAl_3$) phase and alloys of niobium with 40, 50 and 60% Ti, and also at

the point of intersection of the Nb-$\alpha_2$ ($Ti_3Al$) and Ti-$NbAl_3$ phases. The alloys were produced in a laboratory arc furnace with a tungsten electrode on an air cooled copper base in an atmosphere of purified helium at 40 gPa by 4-times remelting of niobium, iodide titanium and A999 aluminum. Isothermal cross sections were constructed by metallographic and radiographic analyses as well as the use of data from the literature. The existence of a trinary $\gamma_1$ ($TiNbAl_3$) phase was confirmed, in equilibrium at 1200°C with the solid β solution based on niobium and β titanium and the $\alpha_2$ ($Ti_3Al$) phase. The polythermal cross sections of Nb-$\alpha_2$ ($Ti_3Al$) and Ti-$NbAl_3$ are partially quasi-binary. The solidus temperature of alloys of niobium with 40-60% titanium at 0-15% aluminum is located at 1650-1750°C or higher. Addition of aluminum decreases the solidus point of Nb-Ti alloys more strongly than addition of titanium. The solubility of aluminum in the solid β solution depends on temperature and titanium (or niobium) content, decreasing from 11% and 40% titanium and 1200°C to 8% at 600°C, 15-16% at 40-50% titanium and 1200°C, decreasing to 10% at 600°C. Figures 2; references 7: all Russian. [65-6508]

WELDING

## NEW VACUUM DIFFUSION WELDING TECHNOLOGY

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 23 Feb 84 p 4

[Article by A. Presnayakov, engineer: "An Experiment Takes Place by Swapping Atoms"]

[Text] "Not only are living tissues incompatible. Try, for example, to weld a ceramic and titanium or nonmagnetic materials to iron. Here even a laser beam is powerless."

The director of the problems scientific research laboratory for vacuum diffusion welding at Moscow Aviation Technology Institute, Professor N. Kazakov, providing explanations, led me to one of the stands. In the demonstration room samples of parts had been assembled for unique apparatus and instruments and electronic equipment, and in each of them the barrier of incompatibility of materials had been overcome.

What constitutes the essence of Professor N. Kazakov's discovery, which immediately became the property of industry? Laser and electron beam welding, which in their time created a revolution in engineering, are based on the melting of metals. However, new research has changed scientists' ideas regarding the physical nature of welds. It has been discovered that interatomic bond phenomena influence the processes of welds, of both similar and dissimilar materials. Because of this, it has been shown that it is possible to weld soft metals--aluminum and copper--without heating. But hard steels, high-temperature alloys and ceramics require heating in the welding process. But heating in open air causes oxidation and nitriding of surfaces, preventing strong bonds.

In order to avoid this, N. Kazakov suggested carrying out heating under vacuum. He formulated the four main conditions for diffusion welding: heating, vacuum, pressure and welding time. The surfaces of two materials placed tightly together under pressure, devoid of "harmful" films, easily swap atoms. Their mutual imbedding takes place. And it is so strong that dissimilar materials are welded dead tight, as they say. The swapping of atoms is a natural process of diffusion. The "glue" of atoms is so strong that when forced tension is applied to parts they tear apart not at the weld but through the base material, which is weaker.

"What are the advantages of the new technology?" I ask N. Kazakov.

"It makes it possible to produce parts with a very complex configuration, including hollow products with various shapes and curvatures, without using fasteners and drilling holes for installing them. After this kind of welding machining is not required, for there is neither scale nor slag. Losses of metal are eliminated. The weight of the construction does not increase, as takes place with ordinary welding, soldering and cementing."

"In vacuum welding the release of radiant energy, gas and finely dispersed dust does not occur. Therefore, the technology eliminates any kind of discharges into the environment."

Associates of the problems laboratory independently and with the participation of specialists from other organizations have created 75 types of equipment for vacuum diffusion welding. Candidate of Technical Sciences V. Bachin acquaints us with one of the latest designs.

Combined in one compact unit are an airtight welding chamber and a system for applying compression pressure to the parts being treated, a vacuum pump and a control panel. An electromagnetic induction field, high-frequency current, radiation, e.g., from the sun, as well as the direct passing of current through the part, can be used for the purpose of heating.

The experiment begins. A part consisting of a ceramic and titanium is placed in the welding chamber. Then the airtight door is closed. Then signals flashed on the mimic panel: The unit is on. The vacuum pump evacuates air from the welding chamber. A button is pressed and the compression system tightly presses one part against the other. The heat source is turned on.

"Soon the 'sandwich'--a 2-layer part--will be ready," V. Bachin explains.

And here I already hold in my hands an exquisitely completed part. Two materials dissimilar in nature have grown together into a single "hybrid." These two "antipodes" cannot be welded by any other methods of welding.

The advantages of the diffusion technology have resulted in the fact that today there is almost no branch of industry where it would not be used for solving complicated engineering problems.

8831
CSO: 1842/77

UDC 621.791.052:539.43:669.295

# FATIGUE RESISTANCE OF JOINTS WELDED BY ELECTRON BEAM WELDING OF TITANIUM ALLOYS VT3-1, VT8 AND VT9

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 2, Feb 84 pp 34-35

STROGANOV, G. B., doctor of technical sciences, POLOSKIN, Yu. V. and IL'CHENKO, G. A., candidates of technical sciences

[Abstract] Welded products are seldom used where load variations are common due to their low fatigue resistance. The present article reports on tests of fatigue resistance in VT3-1, VT8 and VT9 titanium alloys after electron beam welding. Defects and eventual failure were monitored visually and by X-ray and capillary luminescence methods. Where defects were absent, the welded joints suffered declining fatigue resistance in relation to the dimensions of macrogranules, tension, phase composition and hydrogen content. Among these factors, granule size was in direct relation to fractures. Increasing annealing temperature from 540 to 750°C had no effect on fatigue resistance. However, high-temperature annealing in a vacuum was effective in eliminating high hydrogen content and metastable alpha-phase components, thus improving fatigue resistance. Figures 5; references 2: both Russian. [80-12131]

UDC 621.791.72:669.295.002.237

## PERFECTING ELECTRON BEAM WELDING OF VT23 TITANIUM ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 84
(manuscript received 27 May 83) pp 56-58

ZAMKOV, V. N., doctor of technical sciences, SHEVELEV, A. D., candidate of technical sciences, ARSENYUK, V. V., engineer, KUSHIRENKO, N. A., candidate of technical sciences and TOPOL'SKIY, V. F., engineer, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences

[Abstract] Electron beam welding is being used with growing frequency to weld titanium alloys, but some loss in elasticity often results. The present article reports on electron beam welding of VT23 alloy of thicknesses of 10, 30 and 100 mm. Blow resistance of the thermal heating zone and the weld seam consistently was less than that of the basic metal. Attempts to improve this property included changing the seam's chemical composition. The present test used inserts at the joint of 0.5 mm thickness with 10- and 30-mm stock, and of 1 mm with 100-mm stock. With the 10-mm stock results were promising, but with 30-mm and 100-mm samples this approach was not recommended. The inserts also had other drawbacks. Better results were obtained with preliminary melting of edges at 750°C before actual welding, followed by air cooling and age hardening. References 7: all Russian.
[72-12131]

UDC 621.791:72.62-529:669.295

## ELECTRON BEAM WELDING OF PLATE TITANIUM ALLOY PARTS WITH VARYING PROFILE WITH PROGRAMMED CONTROL OF PROCEDURE PARAMETERS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 2, Feb 84 pp 22-23

GERASIMENKO, A. V., engineer, BARYSHEV, M. S., candidate of technical sciences and PSAREV, Yu. I., engineer

[Abstract] Successful automation of welding processes using computer controlled electron beam welding procedures is outlined in the present article. The first step was to develop a suitable mathematical model for various spatial arrangements of electron beams. Good seams were made with plates of up to 100 mm thickness. The second step was to evaluate the functionality of the products during cyclical load fluctuations. This test showed the optimum welding rate to be 18 meters/hour. The actual control program was prepared in the third step. Figure 1; references 4: all Russian.
[80-12131]

UDC: [621.791.72+621.791.754]:669.71:536.422.1

ESTIMATE OF RATE OF THERMAL DECOMPOSITION OF ALUMINUM OXIDE FILM

Kiev AVTOMATICHESKAYA SVARKA in Russian No 12, Dec 83 p 69

TOVMACHENKO, V. N. and OGNYANIK, S. S., candidates of chemical sciences

[Abstract] An estimate is presented of the rate and time of evaporation of aluminum oxide films. The results produced can be used to estimate the behavior of oxide films during welding of aluminum and its alloys both in a vacuum and in various protective media. The rate of evaporation of the oxide film is determined by the rate of diffusion of $Al_2O$ vapor in the gas. References 4: 1 Russian, 3 Western.
[58-6508]

UDC: 621.791.4:539.378.3:[669.295+669.15]:543,422.8

MICROSCOPIC X-RAY SPECTRAL ANALYSIS OF ZONE OF CONNECTION OF TITANIUM WITH STEEL OBTAINED BY DIFFUSION WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 12, Dec 83
(manuscript received 1 Apr 83) pp 54-57

KIREYEV, L. S., engineer, DZYKOVICH, I. Ya., candidate of technical sciences, ZAMKOV, V. N., doctor of technical sciences, and YUR'YEVA, L. S., engineer, Institute of Electric Welding imeni Ye. O. Paton, Ukrainian Academy of Sciences

[Abstract] A study was made to determine the width of intermediate layers at the point of connection of technical titanium with type 2Kh13 and type 12Kh18N10T steel and the specifics of the distribution of individual elements within these layers as a function of welding conditions. Specimens 20 mm in diameter were welded on a type U-874 installation. Statistical processing of the data produced indicated that the width of the intermediate layer for 2Kh18 steel was only about 4 m for one welding mode, and not over 1-2 m for another. No layer of intermetallide was detected for titanium welded to armco iron at a welding temperature of 650-800°C. Best weldability was obtained with ferrite chrome steel. Further studies are required to determine the reason for great decreases in strength which occurred under certain welding conditions, since microscopic x-ray spectral analysis revealed no brittle phases in the contact zones of the specimens. Figures 5; references 5: 4 Russian, 1 Western.
[58-6508]

UDC 621.774.21:621.785

# THERMAL HARDENING OF 1420 x 15-mm SPIRAL-WELDED PIPES MADE OF 17G1S-U STEEL

Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST' in Russian
No 4, Oct-Dec 83 pp 19-20

[Article by L.G. Pozdnyakov, V.V. Tarasov, S.V. Chekhranov, V.A. Atamanenko and V.A. Pestov, IChM MChM SSSR [Institute of Ferrous Metallurgy, USSR Ministry of Ferrous Metallurgy]]

[Text] Type 16GFR steel refined with synthetic slag [1] has been suggested for the purpose of producing thermally hardened pipes 1420 mm in diameter of strength class K-70 in a northern design for pressure of 7.5 MPa. Thermal hardening under optimal conditions of pipes made of this steel [2] makes possible the following level of mechanical properties: $\sigma_y \geq 700$ MPa , $\sigma_t \geq 550$ MPa , $\delta_5 \geq 16$ percent , $a_{n1}^{-60} \geq 0.6$ MJ/m$^2$ , $a_{n11}^{-15} \geq 0.8$ MJ/m$^2$ , and VS [fibrous component] DVTT [expansion unknown]$^{-15} \geq 80$ percent , which makes it possible to reduce the wall thickness of a pipe 1420 mm in diameter to 14 mm and to use thermally hardened pipes instead of pipes made of 09G2FB steel with a wall thickness of 17.5 mm, whose required properties are made possible by controlled rolling of the skelp.

The addition to the steel when making it of up to 0.005 percent boron lowers the quality of the surface of the rolled strip and part of the pipes have to be wasted on lowered quality because of the presence on their surface of scabs, pits and other flaws of metallurgical origin. The required quality of the surface of pipes is obtained by using 17G1S steel for the purpose of producing thermally hardened pipes of strength class K-60 for pressure of 5.5 MPa. It is necessary to determine the suitability of this steel for producing thermally hardened pipes 1420 mm in diameter for pressure of 7.5 MPa in a northern design, i.e., the ability to provide in it the required level of mechanical properties after thermal hardening. For the purpose of improving toughness and ductility properties, the steel must be improved by out-of-the-furnace treatment with synthetic slag, and the sulfur content in the steel must be reduced to less than 0.01 percent.

The guarantee after thermal hardening of ultimate breaking strength and yield strength of not less than 650 and 500 MPa, respectively, makes it possible to reduce the wall thickness of 1420-mm-diameter pipe to 15 mm, with which the pipes must meet the requirements set for northern-design pipes in terms of

elongation, impact ductility and the fibrous component in a DVTT sample at -15 °C.

Type 17G1S-U steel is simpler in composition as compared with 16GFR steel and does not contain scarce alloying elements. Spiral-welded pipes measuring 1420 x 15 mm were made from 17G1S-U steel made by the Novolipetsk Metallurgical Combine. The chemical composition of the steel of the melts used is presented in the table.

Table

| 1) Номер плавки | 2) Содержание элементов, %: C | Mn | Si | S | P | Cr | Ni | Cu | Al | 3) Углеродный эквивалент $C_э$*, % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0,18 | 1,36 | 0,5 | 0,003 | 0,018 | 0,08 | 0,16 | 0,02 | 0,05 | 0,434 |
| 2 | 0,15 | 1,29 | 0,41 | 0,004 | 0,015 | 0,03 | 0,04 | 0,05 | 0,032 | 0,377 |

* Углеродный эквивалент ($C_э$, %) рассчитывался по формуле 4)

$$C_э = C + \frac{Mn}{6} + \frac{V+Mo+Cr}{5} + \frac{Ni+Cu}{15}.$$

Key:

1. Number of melt
2. Content of elements
3. Carbon equivalent
4. The carbon equivalent is calculated by the formula

The pipes were subjected to thermal hardening at the Volzhskiy Pipe Plant under the following conditions: temperature of heating for hardening--940 °C, consumption of water in hardening--820 $m^3/h$, tempering temperature--530 °C. The level of mechanical properties was determined in cylindrical specimens 10 mm in diameter and in impact-bending samples measuring 10 x 10 x 55 mm with a notch radius of 0.25 mm (type 11) and 1 mm (type 1), taken across the pipe's axis:

| | $\sigma_v$, MPa | $\sigma_t$, MPa | $\delta_5$, % | $\Psi$, % |
|---|---|---|---|---|
| Melt 1--hot-rolled state | 520—520 * / 520 | 345—345 / 348 | 32,9—35,2 / 34,0 | 71,7—72,0 / 71,6 |
| Melt 2--thermally hardened | 670—690 / 683 | 510—540 / 528 | 24,0—25,2 / 24,5 | 76,6—77,4 / 77,1 |

*Numerator--minimum and maximum values of tests; denominator--mean values.

A study of impact ductility and of the amount of the fibrous component in the fracture when testing samples over the temperature range of +20 to -100 °C in the initial state and after thermal hardening of the pipes showed (fig 1) that the impact ductility of thermally hardened remains high and equals higher than 1.3 $MJ/m^2$ in samples of type 1 and higher than 0.6 $MJ/m^2$ of type 11, right down to a testing temperature of -100 °C, which testifies to high resistance to brittle failures. The impact ductility of thermally hardened pipes is considerably higher than in the initial (hot-rolled) state over the entire temperature range. This advantage is especially marked at negative temperatures (-20 °C and below). For example, at -20 °C the difference in values of impact ductility between the thermally hardened and hot-rolled

state in samples of type 11 equals 0.75 MJ/m$^2$ at -40 °C, and at -60 °C, 1.6 to 1.7 MJ/m$^2$. At -80 and -100 °C impact ductility is reduced both in the hot-rolled and thermally hardened states; however, whereas in the hot-rolled state it reaches a catastrophically low value (0.07 to 0.05 MJ/m$^2$), in the thermally hardened state it is higher by an order of magnitude--0.7 to 0.6 MJ/m$^2$.

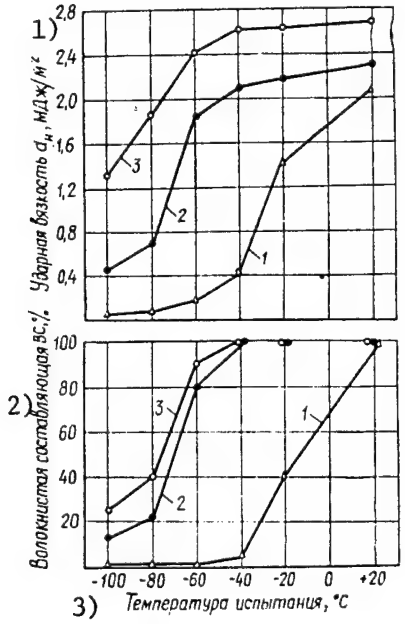


Figure 1. Variation in Impact Ductility, $a_n$, and Amount of Fiber in Fracture, VS, of 1420 x 15-mm Pipes Made of 17G1S-U Steel as Function of Testing Temperature: 1--hot-rolled state; 2, 3--thermally hardened; (1, 2--samples of type 11; 3--of type 1)

Key:
1. Impact ductility, $a_n$, MJ/m$^2$
2. Fibrous component, VS, %
3. Testing temperature, °C

A considerable advantage of the method of thermal hardening of pipes over hot rolling is evidenced in studying the kind of fracture. For example, already at a testing temperature of -20 °C in the hot-rolled state the percentage of the tough component in the fracture is less than 50 percent, and at -40 °C and below the fracture becomes totally crystalline. The thermally hardened state (cf. fig 1) is characterized by completely tough fracture in the temperature range of down to -40 °C; at -60 °C there is not less than 80 percent of the fibrous component in the fracture, and only at a testing temperature of -80 and -100 °C is the percentage of the tough component in the fracture reduced to 50 percent and below.

An evaluation of the cold resistance of thermally hardened pipes made of hot-rolled 17G1S-U steel in terms of the temperature position of the nominal

brittleness threshold, $T_{50}$ (50 percent fiber in the fracture of impact-tested samples), shows that $T_{50}$ is set at -10 °C for the hot-rolled state and -70 °C for the thermally hardened state, i.e., thermal hardening shifts the cold resistance threshold by 60 °C in the direction of negative temperatures. The same dependence is characteristic also of the impact ductility value, if an impact ductility value of 0.6 MJ/m$^2$ for samples of type 1 and 0.3 MJ/m$^2$ for samples of type 11 is used as the value of the nominal cold resistance threshold.

Tests of DVTT samples at a temperature of -15 °C showed that the percentage of the tough component in the fracture is at a level of 100 percent, which satisfies the requirements imposed on pipes designed for pressure of 75 MPa in a northern design ($DVTT^{-15}_{VS} \geq 80$ %).

By determining the components of impact ductility--the work for the origin, $a_z$, and the work for the development, $a_r$, of a crack--in 10 x 10 x 55-mm specimens with a Charpy notch (type 11), it was established by the method of oscillographing (fig 2) that $a_z$ remains high (greater than 0.8 MJ/m$^2$) for hot-rolled 17G1S-U steel only at -20 °C. At -40 °C it is reduced to a level of 0.3 MJ/m$^2$, and with a lower temperature it drops to a zero value. In the thermally hardened state 17G1S-U steel has considerably greater work for the origin of a crack, which practically does not change right down to a testing temperature of -60 °C and equals at this temperature more than 0.9 MJ/m$^2$, and only at -80 and -100 °C is it reduced to 0.6 MJ/m$^2$.

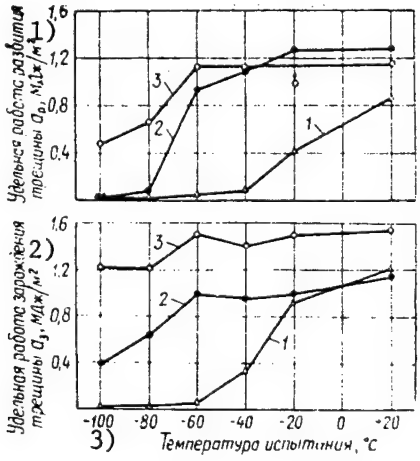


Figure 2. Change in Specific Work Spent on Origin, $a_z$, and Development, $a_r$, of a Crack in Low-Temperature Tests of 17G1S-U Steel: Designations the same as in fig 1.

Key:

1. Specific work for crack development, $a_r$, MJ/m$^2$
2. Specific work for origin of crack, $a_z$, MJ/m$^2$
3. Testing temperature, °C

The work for the development of a crack in thermally hardened steel at temperatures of from +20 to -60 °C is considerably higher (from 0.3 to 0.95 $MJ/m^2$) than for hot-rolled steel, but at -80 and -100 °C it is reduced to the level of hot-rolled metal in samples with a sharp notch (type 11).

The amount of work for crack development in samples of type 11 in the temperature range of +20 to -60 °C is considerably greater in the thermally hardened metal (by 0.1 to 0.3 $MJ/m^2$) than the amount of work for the origin of a crack. At a temperature of -80 and -100 °C the reverse effect was observed: The amount of work for the origin of a crack is considerably greater than the amount for development of it. The reverse relationship is observed for hot-rolled steel: The amount of work for the origin of a crack over the temperature range of +20 to -20 °C is somewhat greater than the amount of work for the development of a crack, and at testing temperatures of -60 °C and below the amount of work for both the origin and development of a crack is equal and approaches zero.

The specific work for the origin and development of a crack determined in testing samples of type 1 (Mesnager notch) proved to be higher than the values of these characteristics found in samples of type 11 (Charpy notch). This speaks for the dependence of $a_z$ and $a_r$ on the type of concentrator, which must be taken into account in evaluating the quality of the metal.

Proving ground tests performed at VNIIST [All-Union Scientific Research Institute of Construction of Trunk Pipelines] confirmed the high reliability of thermally hardened pipes measuring 1420 x 15 mm, made of 17G1S-U steel.

Industrial production of thermally hardened pipes of this size range is slated to be performed in 1983-1984 at the Volzhskiy Pipe Plant.

## Conclusions

Thermal hardening of pipes measuring 1420 x 15 mm, made of 17G1S-U steel, considerably improves the entire combination of mechanical properties, which meets the requirements imposed on 1420-mm-diameter pipes for pressure of 7.5 MPa in a northern design. This makes it possible to recommend 17G1S-U steel for the production of thermally hardened pipes of strength class K-65-70 for trunk pipelines with heightened pressure parameters with a utilization temperature of down to -15 °C.

The anticipated saving from reducing the wall thickness of the pipes (by 15 percent and more) equals more than 25 rubles/t.

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8831
CSO: 1842/69

LABOR-INTENSIVE METAL PRODUCT PRODUCTION PLANNING SYSTEM CHANGE ASSESSED

Moscow MATERIAL'NO-TEKHNICHESKOYE SNABZHENIYE in Russian No 12, Dec 83 pp 27-30

[Editorial by V. Pankrushin, USSR deputy minister of ferrous metallurgy, Moscow: "Relative Tons"]

[Text] A detailed discussion of the effectiveness of planning and evaluating the fulfillment of the plan for the production of metal in relative tons has been conducted in the pages of our journal (No 12, 1982; Nos 3, 7, 8, 9 and 10, 1983).

The results of this discussion are presented by a member of the journal's editorial board, USSR Deputy Minister of Ferrous Metallurgy V.I. Pankrushin.

At the November 1982 Plenum of the CPSU Central Committee our ministry was justly criticized for the fact that it has not been satisfying to the full extent the national economy's demand for metal products and has been thwarting the plans for the output of many kinds of rolled products. And although in the present year the situation with fulfillment of the State quota has improved somewhat, it cannot be said that all difficulties are behind us. The fact is that a further growth in the pace of production of cast iron, steel and rolled products will not produce the proper result. Furthermore, under conditions of limited natural resources this route is becoming most labor intensive and expensive.

What is the way out? Of course, by increasing the output of economical kinds of metal, which as compared with the traditional are distinguished by heightened strength properties and a special range of sections. Rolled products made of low-alloy steel, roll-formed sections, sheet steel with different kinds of coatings and other labor-intensive kinds of metal products will provide consumers an opportunity to reduce the specific consumption of materials for products and to save an amount of metal which is tantamount to a substantial addition to this provided by metallurgists. Last year, for example, it equaled more than 700,000 tons of finished rolled products.

It must be said that quotas for the production of individual kinds of labor-intensive metal have been set for metallurgists before. This directed work teams to increase the output of these products and better coordinated plans for the range of products with the demands of the national economy and the presence of financial resources. However, these quotas did not touch upon a genuine indicator for planning and evaluating the work of rolled products production as a whole, because prior to last year both were done in physical tons. Therefore, other things being equal, the output of heavy sections guaranteed for an enterprise fulfillment of the production quota and winning a prize.

This had a very simple explanation. Effective kinds of metal products are more labor intensive to manufacture but do not produce a saving for a metallurgical enterprise. It is gotten by the consumer. At the same time, the utilization of mills in producing these sections remains the same as in rolling a simple and heavy one. However, more of the latter are produced in physical tons per unit of time. Therefore, in order to fulfill the quota as quickly as possible, plants attach priority to rolling metal in simple and heavy sections. And when the quota had been fulfilled, they forgot, as it were, about making labor-intensive kinds of products.

As a result, the national economy as a whole has suffered. Many consumers, not having received the metal that they needed, had to use rolled products which were not of the sizes and shapes which they required. And hundreds of tons of metal went into chips and waste.

Of course, physical tons are the simplest and most convenient indicator for planning and reporting the work of rolled products production. This indicator provides a unified basis for developing plans for production and material balances and plans for the distribution of rolled products and makes it possible to accomplish accounting and control of actual production and of the shipment of products on the basis of various transport, payment and other documents.

On the other hand, this indicator poorly reflects the labor intensiveness of production and the consumer value of products. Solution of this problem is a very complicated task, because both one and the other are characterized by many factors and parameters which it is practically impossible to reflect in a single indicator. In ferrous metallurgy the search is constantly on for more ideal indicators which would reflect at least some of the most important production conditions and the consumer properties of metal products. For example, at many enterprises an estimate of the output of rolled products in terms of theoretical weight has been developed and been in use for a long time. This has made it possible to provide incentives for the operation of rolling mills in the area of negative tolerances.

The most large-scale measure for the introduction of new indicators in rolled products production has been the changeover to planning and evaluating fulfillment of the quota in relative tons, taking into account the labor intensiveness of the product range. The first seven of our enterprises, including

the Krivoy Rog imeni V.I. Lenin, the Kommunarsk and other metallurgical plants, were converted to this system as of the First of January of last year. At the present time planning and evaluating fulfillment of the plan in relative tons are being carried out at a few dozen enterprises of the industry, which produce about 99 percent of all finished rolled products. The changeover of the remaining enterprises where rolled products production takes place will also be completed shortly.

It must be mentioned that there is nothing new in the relative tons indicator itself. Much has been said about it and methods of calculating it in reports in the pages of our journal, as well as of other specialized literature. This indicator has been used for a long time in the practice of intraplant planning, but today it has emerged as the main estimate of fulfillment of the plan for production of rolled products. And the indicator for the output of rolled products in physical tons has remained a calculation indicator.

With the new system, metallurgical enterprises, if orders for labor-intensive kinds of rolled metal products are disrupted, even if the calculated physical tons have been reached, will not fulfill the quota, which will lead to all the resulting consequences. Interest of work teams in producing labor-intensive and economical kinds of products is created in this manner.

In our opinion, it is still too early to talk about the effectiveness of the new system of planning. In such a short time the positive effect of the new indicator has not been evidenced at all enterprises to the full extent. In addition, last year the industry worked unsteadily. And nevertheless this system provided an opportunity to coordinate closely the plan and orders and to make the entire range of rolled products equally profitable. The interest of work teams in completing orders for the most labor-intensive and economical kinds of rolled products was increased drastically.

The results of the industry's work in the present year speak in behalf of planning in relative tons. The production of low-alloy rolled products and of thermally hardened metal increased by hundreds of thousands of tons as compared with the same period last year, in only the first eight months. The percentage of labor-intensive sections increased considerably at the Magnitogorsk imeni V.I. Lenin and Novolipetsk metallurgical combines. All this resulted in a reduction of the thickness of rolled sheet products and the weight of one linear meter of rolled bar products. Their specific consumption of metal was reduced by more than 700,000 tons, and the level of the completion of orders reached almost 98 percent. This by far exceeds the analogous indicator over a period of many years. Now it can be stated confidently that the system is working toward the completion of orders.

Much has already been done for the purpose of introducing the new system of planning. The nomenclature of rolled product section and size groups and hourly productivity standards and labor intensiveness factors according to which the output of rolled products in relative tons is to be planned and accounted for have been developed, coordinated and approved by the USSR Gosplan and our ministry for practically all metallurgical enterprises. The

wage system and intraplant planning have at a number of enterprises been brought into conformity with the new indicator for planning and evaluating fulfillment of the plan.

However, it must not be thought that the use of relative tons as an evaluation indicator is a sufficient condition for total satisfaction of the national economy's demand for rolled metal products. Along this road it is still necessary to solve not a few problems on both the methodological and organization planes. Let us say, at the present time the workload of rolling mills at metallurgical enterprises is calculated in relative tons. But consumers continue to receive funds for metal in physical tons. In order to assign them properly to suppliers, it is necessary to balance production in relative tons and distribution in physical tons. This job must be performed by soyuzglavsnabsbyts [main administrations for supply and marketing], but they are not yet ready for it.

For example, in the first quarter of the present year the USSR Gosplan did not distribute all kinds of economical sections by ministries and departments, and they did not deliver them to their enterprises. As a result, quotas for the introduction of these sections turned out to be not specified for agencies of the USSR Gossnab. Therefore, the soyuzglavsnabsbyts did not provide the plan for the production of economical kinds of rolled products with the required number of orders. The capacities of metallurgical plants proved to be underutilized by more than 350,000 tons of rolled products made of low-alloy grades of steel, and capacities for thermal hardening of reinforcing-bar steel have been underutilized.

Because of the lack of specifications, the Krivoy Rog Metallurgical Plant imeni V.I. Lenin was not issued a single order for shipment of thermally hardened carbon steel. In terms of its mechanical properties it corresponds totally to steel alloyed with manganese. The USSR Gossnab allowed the enterprise to ship this product to fill orders for low-alloy steel. And meanwhile thermal facilities for hardening reinforcing-bar steel are standing idle at the plant.

The plate foundry of the Magnitogorsk Metallurgical Combine does not have enough orders for the thinnest plates (0.20 to 0.22 mm). The situation with other metal product size ranges is similar at this enterprise.

The existing assignment system has resulted in the fact that not a single consumer ministry has been enlisted for this work. They simply do not know what their subdepartmental enterprises have specified and today are not ready to carry out a technical policy in questions relating to the consumption of metal, to expand the utilization of economical kinds of rolled products and to find ways of substituting scarce metal with less scarce. Soyuzglavmetall [Main Administration for Supply and Marketing of Metal Products] also does not possess this information, since almost two thirds of orders are formed via territorial supply and marketing organizations and existing longterm direct business relationships.

In turn, territorial agencies of the USSR Gossnab are not able to determine the validity of the consumption of metal products ordered by a consumer. Moreover, in terms of its own position, the USSR Gossnab does not have the right to introduce changes in specifications issued by a consumer.

Thus, today control over the advisability of the consumption of a specific kind of rolled product has been lost. And personnel of enterprises often order a product not needed by them and constantly strive at any cost to increase funds for metal. The reckoning here is simple: What is not needed can always be exchanged for another type or for any other material. As a result, transportation runs are increased and at the same time there is a growth in the stock at enterprise warehouses, which has a negative effect on their economics. Neither Soyuzglavmetall nor territorial agencies of the USSR Gossnab are able to keep an eye on the validity of orders.

Under conditions of a shortage of ferrous metallurgy capacities and limited resources it is necessary to strengthen the responsibility of industry consumer ministries for the efficient utilization of metal products. Here it is necessary that the entire job of specifying funds be performed only through them, since only they themselves can in a skilled manner examine the validity of specifications presented and they hardly need an intermediary in the form of Soyuzglavmetall or a territorial agency of the USSR Gossnab.

In our opinion, the work of planning and design organizations should also be restructured. They are obligated to see to the fuller utilization of economical kinds of metal products in designs under development and in the designs of machines and machinery. Standards for designing and planning should also be reviewed for the purpose of reducing the specific consumption of metal for newly created products.

Apparently, restructuring of the work of supply and marketing organizations of the USSR Gossnab is also necessary. Their task, in our opinion, is to study the national economy's demand for metal with regard to types, sections and dimensions, and to carry out a firm policy aimed at improving the consumption of metal and increasing the utilization of economical kinds of rolled products taking into account total utilization of capacities for producing them. It is our firm conviction that the work of agencies of the USSR Gossnab should in no way be limited to the statistical processing of orders.

The USSR Gosplan should distribute funds for all kinds of economical sections and the USSR Gossnab should organize record keeping for their assignment by fund holders. It is also necessary to put in order record keeping of fulfillment of the plan for production of rolled products, including economical types of them. For this purpose it is necessary that enterprises indicate the number of orders which have arrived on form 2-P, "Report on Production of Ferrous Metal Rolled Products by Kinds." Now on this form is indicated a production plan which does not correspond to the actual workload of orders which enterprises have, and the principal indicator of their work has now become the fulfillment of contract obligations.

For purposes of ensuring an optimal workload of orders for metallurgical plants, in the marketing departments of supply and marketing organizations of the USSR Gossnab it is necessary to keep account of orders issued in terms of labor intensiveness. Prior to the introduction of an automated production control system, this accounting can be limited to at least the most labor-intensive kinds of the product range and to a coordinated list of economical kinds of rolled products.

One more question which arises in the capacity of a production process for labor-intensive kinds of metal products is more efficient coordination of the actions of the USSR Gosplan and USSR Gossnab in devising and adjusting the plan for the production of rolled products. Experience in the operation of enterprises converted to the new system has shown that if the USSR Gosplan does not take into account in production plans the national economy's demand for a full-scale product range, then great difficulties arise, in the utilization of rolling mills, in adjusting the plan and funds, and the USSR Gossnab does not have a specified demand by the instant the plan is drawn up.

Last year, for example, at enterprises which worked according to the system of planning in relative tons there was a considerable increase in loading of mills with labor-intensive rolled products. According to the existing instructions the plan for the output of rolled products in physical tons should have been reduced by more than 700,000 tons. However, this was not done. Therefore, at the stage of formation and approval of the plan the USSR Gossnab was obligated to present to the USSR Gosplan information on the national economy's demand for rolled products for the period being planned, in a full-scale range of products. And when the actual workload of rolling mills in terms of labor intensiveness entails changing the calculated plan in physical tons, the USSR Gossnab and USSR Gosplan in keeping with the existing instructions must adjust the plan and the funds.

Now practically the entire industry has changed to planning in relative tons. Of course, the new system has still not been totally perfected. But its advantages are obvious. The national economy is receiving more effective rolled product sections. Consumers have an opportunity to order metal in the range of products they require. A qualitative change for the better has taken place in supplying enterprises with advanced types of metal products. Therefore, it is necessary to improve still further the system of planning and evaluating fulfillment of the production plan in relative tons.

First of all it is necessary to eliminate the difficulties in formation of the specified demand for metal products and in assigning them. More precise coordination of the actions of planning agencies is also necessary. All these problems must be solved by the combined efforts of the USSR Gosplan, USSR Gossnab and the USSR Ministry of Ferrous Metallurgy.



8831
CSO: 1842/67

UDC: 669.15'24:539.213

## RELAXATION TRANSITIONS IN AMORPHOUS IRON AND NICKEL-BASED ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 10 Jan 83) pp 82-85

MALINOCHKA, Ye. Ya., DURACHENKO, A. M. and BORISOV, V. T., Moscow

[Abstract] Amorphous strips of the alloys Fe+40 at.% Ni+20 at.% B and Fe+10 at.% Ni+13 at.% P+7 at.% C were obtained by spinning and powders of the same alloys were obtained by the pulsed plasma channel method. The sheets were about 30 μm thick, the mean particle diameter of the powder about 10 μm. Differential scanning calorimetry curves of the specimens show no thermal relaxation effect. A change in heating rate leads to displacement of λ points, indicating the activation nature of the processes responsible for appearance of the points (areas of anomolous change of heat capacity in a narrow temperature interval). Comparison of curves of the specimens before and after heat treatment reveals that the λ points separate areas with exo- and endothermic effects corresponding to the occurrence of relaxation processes. The possibility of alteration of the magnetic structure of the material upon transition is noted. Figures 3; references 5: 3 Russian, 2 Western.
[65-6508]

UDC: 669.3'783:539.213

## ELECTRONOGRAPHIC STUDY OF STRUCTURE OF AMORPHOUS Cu-Ge ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 19 Jan 83) pp 178-184

PANOVA, N. N., POPEL', S. I., NEGODAYEVA, N. Yu., Sverdlovsk

[Abstract] Electronography was used to study the structure of amorphous films of Cu-Ge alloy obtained by thermal atomization onto a cold copper substrate. The film thickness of about $5 \cdot 10^{-8}$ m allowed production of a diffraction picture characteristic for massive specimens. In order to

determine the extent to which changes in structure of the specimens influence the shape of the curves produced, Fourier transforms were used to obtain different functions of radial distribution of the atoms. It is found that the mean statistical ordering of dissimilar atoms can be interpreted based on fragments of the structure of the high-temperature η phase using an icosahedral model with the figures articulated along a common edge and preferential location of copper atoms around the germanium atom. Directed zigzag chains of dissimilar atoms are observed resulting from the covalent component of the interaction. The excess germanium atoms are located in singular areas neighboring the icosahedral areas. As the content of germanium increases, the form of ordering of the germanium atoms becomes more complex, stabilizing the structure of amorphous Cu-Ge alloys rich in germanium. Figures 3; references 11: 6 Russian, 5 Western.
[65-6508]

UDC: 669.27-151:669.046.54

## BURNING TIME OF A TUNGSTEN FILAMENT AS A FUNCTION OF ITS STRUCTURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 84 (manuscript received 17 Jan 83) pp 170-173

BURKHANOV, G. S., MORDYUK, V. S., RUCHIN, V. I., SINITSYN, G. F., Moscow

[Abstract] The variation of burning time of polycrystalline and single crystal tungsten filaments as a function of temperature is studied under vacuum. Wire 88-100 μm in diameter with a fine grained structure, mean grain size 30-40 μm, was studied. Comparative measurements of burning time of recrystallized specimens with fine grain structure plus single and dual crystalline structure were performed at 1900-3000°C in a vacuum with a residual pressure of $10^{-2}$-$10^{-4}$ mm Hg. Thermodynamic calculations and experimental results indicate that active oxidation and atomization of tungsten occurs at 2300-2800°C. The burning time of single- and dual-crystal specimens was significantly greater than that of fine-grained specimens in atmospheres contaminated with carbon and oxygen impurities. The rate of atomization decreases in a low vacuum as structure changes from fine grained to single- and dual-crystalline, confirming the importance of grain boundaries in the interaction between the tungsten and active gas impurities in the residual atmosphere. Figures 5; references 11: 10 Russian, 1 Western.
[65-6508]

UDC: 669.14.018.6

ALLOYS OF TUNGSTEN AND MOLYBDENUM WITH RHENIUM FOR ELASTIC INSTRUMENT PARTS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 2, Feb 84 pp 46-48

SAVITSKIY, Ye. M., TYLKINA, M. A., KAZANSKAYA, N. K., Institute of Metallurgy imeni A. A. Baykov

[Abstract] A study was made in order to find alloys for particularly long elastic elements which largely determine the accuracy, reliability and durability of instruments. Alloys were developed based on the state diagrams and composition and properties diagrams of tungsten and molybdenum plus rhenium systems. The alloys produced are saturated binary and trinary solid solutions with body-centered cubic lattice, manifesting the "rhenium effect," simultaneous increases in strength and ductility and decreased temperature of transition to the brittle state, with retention of ductility after recrystallization and welding. This allows the production of a group of very high strength yet workable alloys. Alloys in the system W-Mo-Re are found quite promising as materials for micron cross section elastic elements with a combination of high strength and minimum resistance to torque. Heating of the wires to temperature of not over 500°C increases their tendency toward concentrated deformation. Figures 2; references 7: all Russian. [68-6508]

UDC 541.124+546.26

ROLE OF CATALYST IN PROCESS OF TRANSFORMING GRAPHITE INTO DIAMOND UNDER HIGH PRESSURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 20, No 1, Jan 84 (manuscript received 17 Jun 82) pp 63-66

KOROLOV, D. F., BELIMENKO, L. D. and KLIYENTOVA, G. P., All-Union Scientific Research Institute for Synthesis of Mineral Raw Materials

[Abstract] In diamond synthesis, previous authors have either denied or neglected the role of catalysts. While the formation of carbide resulting from the reaction of metal and graphite had been studied in general terms, the authors here give detailed attention to individual stages in the reaction to obtain new information on the role of metal catalysts in producing synthetic diamonds. An Ni-Mn catalyst was included with graphite and subjected to increasing pressure and heat. Various amounts of graphite permeated the alloy with high pressure (4.4 HPa) alone. Initial crystalline graphite became highly amorphized and nearly amorphous. Heating to 700-800°C brought a reaction forming transitional carbide. As heat rose to 1100°C, diamonds crystallized in graphite disks near the contact with the metal, and after 20 minutes a metastable graphite form predominated, which formed into

octahedrons. The metal catalyst participated in the transition of crystalline graphite into amorphous form, and subsequently into actual diamond production. On the other hand, themetal contributed to recrystallization of graphite into disk-like, metastable form that blocked diamond growth. Figures 3; references 14: 12 Russian, 2 Western.
[79-12131]

UDC 541.12.034:666.233.091

EFFECT OF CONDITIONS OF SHOCK-WAVE CRYSTALLIZATION ON PHYSICO-CHEMICAL PROPERTIES OF BORON NITRIDE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 20, No 1, Jan 84 (manuscript received 18 Dec 81) pp 152-155

SAVVAKIN, G. I. and SERDYUK, V. A., Institute of Problems of Materials Studies, UkSSR Academy of Sciences

[Abstract] Questions of formation of highly defective crystalline and amorphous structures during explosions include two classes of irreversible processes: destruction and emergence of nearly balanced structures, and formation of highly unbalanced structures under special external and internal conditions. The present study reports on the structure and physico-chemical properties such as optics, caking tendency and phase stability for hexagonal boron nitride and variations. Pressure increase was regulated by changing porosity of the powder layer from 40-50% to as low as zero, and the intensity of the shock wave was also varied. Infrared spectra, which agree with those reported earlier, show breaks in the initial hexagonal structures and other distortions. Rapid increases in the density of structural defects and distortions brought increased caking tendency and stability in the forms of boron nitride that resulted from shock wave exposure. Figure 1; references 9: all Russian.
[79-12131]

UDC 546.56.231:537.311.3

ELECTRICAL CONDUCTIVITY AND THERMO-ELECTROMOTIVE FORCE OF COPPER SELENIDE, ALLOYED WITH SELENIUM, IN SOLID AND LIQUID STATES

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 20, No 1, Jan 84 (manuscript received 11 Jul 82) pp 167-168

BURKHANOV, A. S., GLAGOLEVA, N. N., KURESHOV, V. A., Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy

[Abstract] Production of desired semiconductors requires study of their melted states. Cu Se, with its high melting point of 1386°K with retention

of semiconductor properties, is of special interest. The authors studied the dependency of electrical conductivity and thermo-electromotive force with compounds containing 0.5, 1 and 1.5% atomic weight above stoichiometry, as well as a stoichiometric sample. Results showed that all test samples had a negative temperature coefficient of conductivity except the stoichiometric one. Compensating factors of increased charge carrier dispersion and growth in concentration were used to explain the lack of a temperature dependency in the liquid state of the samples. The greatest thermo-electromotive effectiveness was found with 0.5% added selenium by atomic weight beyond stoichiometry. Figures 3; references 4: all Russian.
[79-12131]

UDC: 621.789:669.14.018.25

INFLUENCE OF THERMOMECHANICAL TREATMENT ON STRENGTH OF U8A STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 2, Feb 84 pp 31-34

SUMINA, I. I., Kostroma Agricultural Institute, "Karavayevo"

[Abstract] Studies were performed on commercially produced eutectoid U8A steel. Four groups of specimens with different austenite grains were obtained by varying the rate of heating during heat treatment and the deformation temperature during high temperature thermomechanical treatment, with a constant degree of deformation of 35%. Tempering was performed at 250 and 650°C. The results of these studies showed that with a decrease in austenite grain size from No. 4-5 to No. 13-14 impact toughness increases after heat treatment and after thermomechanical treatment in all cases. The studies demonstrate that impact toughness is significantly influenced by austenite grain size and by grain formation conditions. Greatest impact toughness is observed after direct thermomechanical treatment. Figures 2; references 3: all Russian.
[68-6508]

UDC: 669.725:620.174.24

INFLUENCE OF IMPURITIES ON HIGH TEMPERATURE FAILURE OF STRUCTURAL BERYLLIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 2, Feb 84 pp 41-43

NOVOSELOVA, A. V., FRIDLYANDER, I. N., NAGORSKAYA, N. D., YATSENKO, K. P., MOLCHANOVA, L. V. and KOLESNIKOVA, V. I.

[Abstract] It has been found that commercial beryllium includes a number of metal phases formed in the presence of impurities which influence its properties. The chemical composition and properties of these phases depend not only on the concentration of impurities but also on thermomechanical treatment of the material. If the total percentage of Fe+Cr+Mn is at least 2.4 times as great as the percentage of Al present, beryllium can be produced which is resistant to high-temperature failure. A material with iron content 1.9 times as great as Al content has a tensile strength of 400-430 MPa, $\delta$ 1.5-2.5%, 250 heating and cooling cycles before failure in testing. Figures 2; references 5: 2 Russian, 3 Western.
[68-6508]

UDC: 621.762

SOME MECHANICAL PROPERTIES OF SILICON CARBIDE FIBERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 1, Jan 84 (manuscript received 26 Jul 82) pp 55-59

DOROKHOVICH, V. P., KOPAN', V. S. and SILENKO, P. M., Institute of Material Science Problems, Ukrainian Academy of Sciences

[Abstract] Silicon carbide fibers are produced by chemical precipitation from the gas phase onto a moving conductive substrate. These fibers have high modulus of elasticity, 441.3-490.3 GPa. They are also highly resistant to oxidation in air. This work discusses the strength, creep, recrystallization and mechanical luminescence of these fibers. The strength of the fibers tested was practically constant throughout their length. When fibers were processed in contact with mercury which had water on its surface the strength decreased. Contact with hydrochloric acid had the same effect. Microscopic examination revealed pits about $10^{-6}$ m in depth. This surface erosion decreases fiber strength to one-half to one-third of normal strength. Creep is found to be near zero at room temperature, $\Delta l/l \approx 10^{-7}$ day$^{-1}$ at 1173°K. Figures 8, references 14: 6 Russian, 8 Western.
[64-6508]

UDC 621.793.6:838.12

EFFECT OF PROTECTIVE COATINGS ON MECHANICAL PROPERTIES OF HEAT-RESISTANT ALLOYS

Kiev PROBLEMY PROCHNOSTI in Russian, No 1, Jan 84
(manuscript received 10 Mar 83) pp 100-103

GUZANOV, B. N., SOROKIN, V. G. and KOSITSYN, S. V., Scientific Research Institute for Heavy Machinery, Sverdlovsk

[Abstract] Applying coatings to heat-resistant alloys can be regarded as creating a new composite material with properties that differ from those of the original protected alloy; these properties depend on the manner of applying coatings, subsequent thermal processing, the nature of the phases formed, etc. The present article reports on blade alloys EI893 and EI929, produced for stationary gas turbines. A thermal diffusion method was used to apply coatings of ferro-alloys and traditional aluminide coatings, as well as the proposed alumosilicide coatings. Results showed that the protective coatings had little impact on alloy durability during short-term tests. In longer tests, the coatings enhanced the alloys' durability. Thermal fatigue was tested in temperatures varying between 150 and 880°C, with constant stretch loading. Coatings improved resistance to creep from failure at 335 cycles with uncoated alloys, to lasting usefulness above 550 cycles for articles coated with alumosilicide. Deformation was limited to 1% before cracking began, but increasing temperature extended the permissible deformation to 2%. The aluminide coating was especially effective in corrosive environments. Figures 5; references 9: all Russian.
[71-12131]

UDC: 620.179

SEGREGATION EFFECTS IN SURFACE LAYERS OF AMORPHOUS STRIPS OF IRON-BASED ALLOYS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84
(manuscript received 28 Mar 83) pp 591-594

SHABANOVA, I. N., SAMOYLOVICH, S. S., ZHURAVLEV, V. A., BORISOV, V. T. and BAYANKIN, V. Ya., Udmurt State University imeni the 50th Anniversary of the USSR, Izhevsk

[Abstract] A study is made of the regularities of segregation of elements in amorphous specimens of alloys of iron, carbon, chromium, potassium and silicon through the depths of the surface layers. The amorphous specimens were produced in the form of strips about 5 mm in width and 30-35 μm thick by hardening from the liquid state on a spinning copper cylinder. The composition of the surface layers was studied on an electron magnetic spectrometer

with a resolution of 1.0 eV. Specimens were preheated to 420-470°K in the spectrometer chamber to remove adsorbed gases and hydrocarbons. The results presented showed that in all cases the surface of the specimens was significantly enriched in carbon, forming primarily the C-C and Fe-C bonds. This is a hereditary picture fixed in the process of hardening of the specimens from the liquid state. Figure 1; references 10: 8 Russian, 2 Western.
[70-6508]

UDC: 546.28

INFLUENCE OF CRUCIBLELESS ZONE MELTING MODE INSTABILITY ON GROWTH AND HETEROGENEITY OF SILICON CRYSTAL

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 19, No 12, Dec 83 (manuscript received 18 Mar 82) pp 1957-1962

DOBROVOL'SKAYA, V. I., MANDEL', V. S. and RATNIKOV, D. G.

[Abstract] The conditions under which crystals are grown in the crucibleless zone melting method are determined by the parameters of the supporting apparatus, including the zone movement rate and inductor voltage. At the moment there are no scientifically well-founded criteria for determining the important characteristic of permissible instability of the process parameters. The purpose of this work was to determine the relationship between instability of process parameters and the quality of silicon crystals and on this basis to estimate the necessary level of process stability. The heterogeneity of distribution of impurities in the crystalline ingot along the growth axis was used as the criterion to evaluate the influence of instability of parameters on crystal quality. Two methods were used to determine the heterogeneity of crystals: electrochemical etching and measurement of variations in resistivity. It was found that fluctuations in voltage have a greater influence on growth and heterogeneity than fluctuations in zone movement rate. Hardware parameter instability of a few percent is harmless, since it does not prevent dislocation-free growth and makes no significant contribution to crystalline heterogeneity. Figures 4; references 3: 1 Russian, 2 Western.
[55-6508]

UDC: 621.315.592

PROSPECTS FOR APPLICATION OF $A^{II}B^{IV}C^{V}_2$ SEMICONDUCTORS FOR PRODUCTION OF SILICON HETEROJUNCTIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 19, No 12, Dec 83 (manuscript received 28 May 82) pp 1967-1972

AVERKIYEVA, G. K., GREKHOV, I. V., KALEVICH, Ye. S., KOSTINA, L. S., PROCHUKHAN, V. D. and SEMCHINOVA, O. K., Institute of Physics and Technology imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] Some 90% of all semiconductor devices are based on silicon. $A^{II}B^{IV}C^{V}_2$ semiconductors, electronic and crystallochemical analogs of silicon, are of interest for the creation of silicon-based heterostructures. This article discusses some of the parameters of compounds of $A^{II}B^{IV}C^{V}_2$ and silicon of significance for the creation of epitaxial layers. $A^{II}B^{IV}C^{V}_2$ compounds with B=Si have a broad forbidden zone and can change conductivity type, and also form large areas of solid solutions with silicon. Heterojunctions have been created in $A^{II}B^{IV}C^{V}_2$ chalcopyrite-structure combinations with silicon. $A^{II}B^{IV}C^{V}_2$-germanium semiconductors are tetrahedral materials with large areas of solid solutions with silicon. Heterojunctions have been created on the basis of solid solutions through the four $B^{IV}$-$A^{II}B^{IV}C^{V}_2$ cross sections on the silicon side. The method of thermal diffusion from the base phase, in which a single crystal of silicon is treated with vapors of volatile II and V group elements at fixed temperature, is most promising for industrial use. References 23: 9 Russian, 14 Western. [55-6508]

UDC: 546.641-31:546.623-31:546:65:535.33

NEW POSSIBILITIES FOR EXCITING STIMULATED RADIATION IN INORGANIC CRYSTALLINE MATERIALS WITH GARNET STRUCTURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 19, No 12, Dec 83 (manuscript received 28 Feb 83) pp 2056-2059

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[Abstract] New lasing properties of crystals with garnet structure have been discovered, yielding additional possibilities for further development of this promising class of inorganic laser materials. In complex studies of three-cation $Ca_3Ga_2Ge_3O_{12}$ garnets, stimulated radiation was excited in the near IR area, related to a previously unknown generation center in these oxygen-containing crystals. This center is characterized by long term stability and has a very intense, narrow-band ($\Delta\nu_{lum} \approx 2$ cm$^{-1}$ at 77K) luminescence at 1.2805 μm. Formation of the center in $Ga_3Ga_2Ge_3O_{12}$ garnet

with $Ca^{2+}$, $Ga^{3+}$ and $Ge^{4+}$ cations may be related to dissociation of $GeO_2$ in the melt during growing of the crystals from platinum crucibles. Spectral generation measurements of the crystals reveal new possibilities for the creation of inorganic oxygen-containing crystals with basically new stimulated radiation properties. Figures 3; references 11: 7 Russian, 4 Western.
[55-6508]

UDC: 548.25:539.232

PROPERTIES OF EPITAXIAL ZINC SELENIDE LAYERS PRECIPITATED FROM DIETHYLZINC AND SELENOHYDROGEN VAPORS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
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[Abstract] Epitaxial zinc selenide layers, both undoped and doped with aluminum, were obtained from vapors of diethylzinc and selenohydrogen, and the photoluminescence spectrum and conductivity of the specimens were studied. Films were obtained in a vertical reactor with a substrate temperature of 653°K, pressure varying from 1 to 500 Pa, rate of precipitation 0.3-10 μm/min. The substrate used was gallium arsenide. The luminescent spectrum was measured by excitation with a helium-cadmium or nitrogen laser. The resistivity of the specimens was found to be over $10^{10}$ ohms per centimeter. Doping with aluminum by adding triethylaluminum at $10^{-3}$-$10^{-5}$ by volume to the diethylzinc reduced the resistivity to $10^{5}$-$10^{-2}$ ohm per cm. The results obtained indicate that the method for precipitation of zinc selenide can produce epitaxial layers of high purity and allows regulation of resistivity over a broad range. Figures 3; references 9: 3 Russian, 6 Western.
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